INSTITUTION NUMBER.

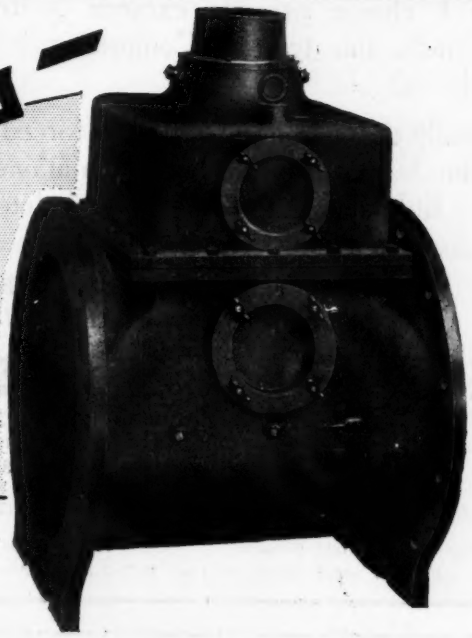
GAS JOURNAL

LIGHT ✦ HEAT ✦ POWER ✦ BYE-PRODUCTS

[Founded in 1849 as the "Journal of Gas Lighting."]

VOL. CXC. No. 3499.] LONDON, JUNE 11, 1930. [82ND YEAR. PRICE 2s.

MEASURING UNPURIFIED GAS



Kent's 'Shunt' Gas Meter meets the difficulties of measuring dirty gas in the simplest possible way, with the consequence that installations of 'Shunt' Meters measuring such gases are invariably satisfactory.

The names of a few of the gas works where Kent's 'Shunt' Gas Meters are metering Water Gas or other unpurified gases with high accuracy and a minimum of trouble are:—

Hertford	Gosport
Berkhampstead	Kilmarnock
Barry	Wellingborough
Watford	Woolwich Arsenal

KENT'S 'SHUNT' GAS METER

The introduction of Kent's 'Shunt' Gas Meter marked a great advance in gas measurement. The ease with which the meter is installed, the small space occupied, the low initial cost, and the proved accuracy form the basis of its increasing popularity.

Write for Publication No. 709/J

GEORGE KENT, LTD., BISCOT ROAD WORKS, LUTON, BEDS.

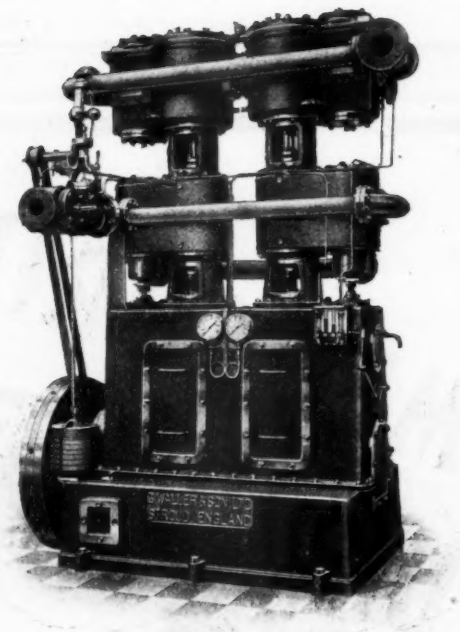
GAS COMPRESSORS

Vertical Enclosed Type

WHEN space is limited and the discharge pressure exceeds 5 lbs. per sq. inch, this type of Compressor is eminently suitable.

Totally enclosed and fitted with forced lubrication, a clean appearance is maintained and very little attention required. Complete range of sizes from 25,000 to 250,000 c.ft. per hour.

SINGLE, DUPLEX, STEAM TANDEM, GAS ENGINE, ELECTRIC, or BELT DRIVE



VERTICAL ENCLOSED DUPLEX COMPRESSOR.
80,000 c.ft. per hour, at 20 lbs. per sq. inch pressure.

Geo. Waller & Son, Ltd.

Phœnix Iron Works, STROUD, GLOS.

Telegrams: "WALLER, BRIMSCOMBE." Telephone: 10 BRIMSCOMBE.

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Telegrams: "Gaslights Glasgow." Telephone: 680 Douglas.

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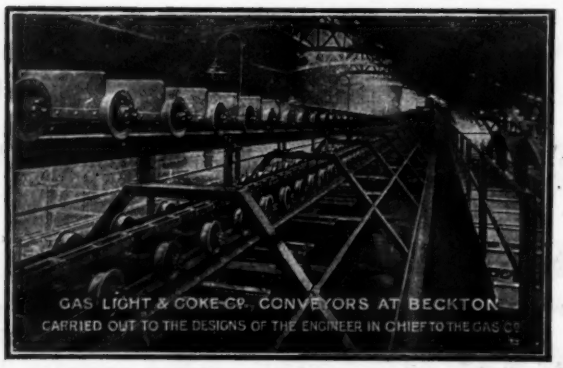
THORNABY-ON-TEES and STOCKTON-ON-TEES

have foundries with an output of over 100,000 tons annually and are specially equipped for turning out

PURIFIERS

PURIFIERS, either luteless or water sealed, GASHOLDERS



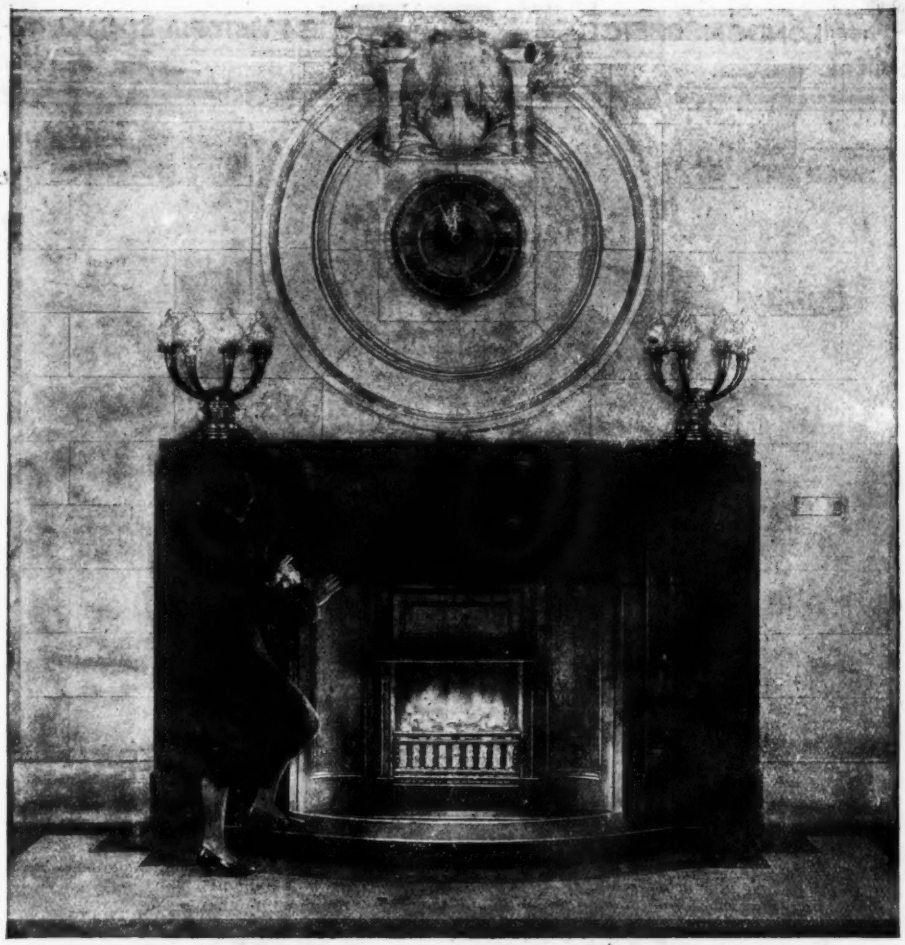
COAL & COKE HANDLING PLANTS, PAN ASH WASHERS, "MARCUS" SCREEN CONVEYORS, etc.

GENERAL GAS PLANT

PUT US ON YOUR ENQUIRY LIST FOR STEEL CASTINGS

London Office: 5, VICTORIA ST., S.W. 1.

COKE FIRES
solve the "smoke problem"



A FLAMING "Metro" smokeless coke fire burning in one of the entrance halls at County Hall, London. "Metro" coke fires are also used to warm some of the wards of the Metropolitan Asylums Board's hospitals. London gas supply undertakings recommend and sell "Metro" coke fires.

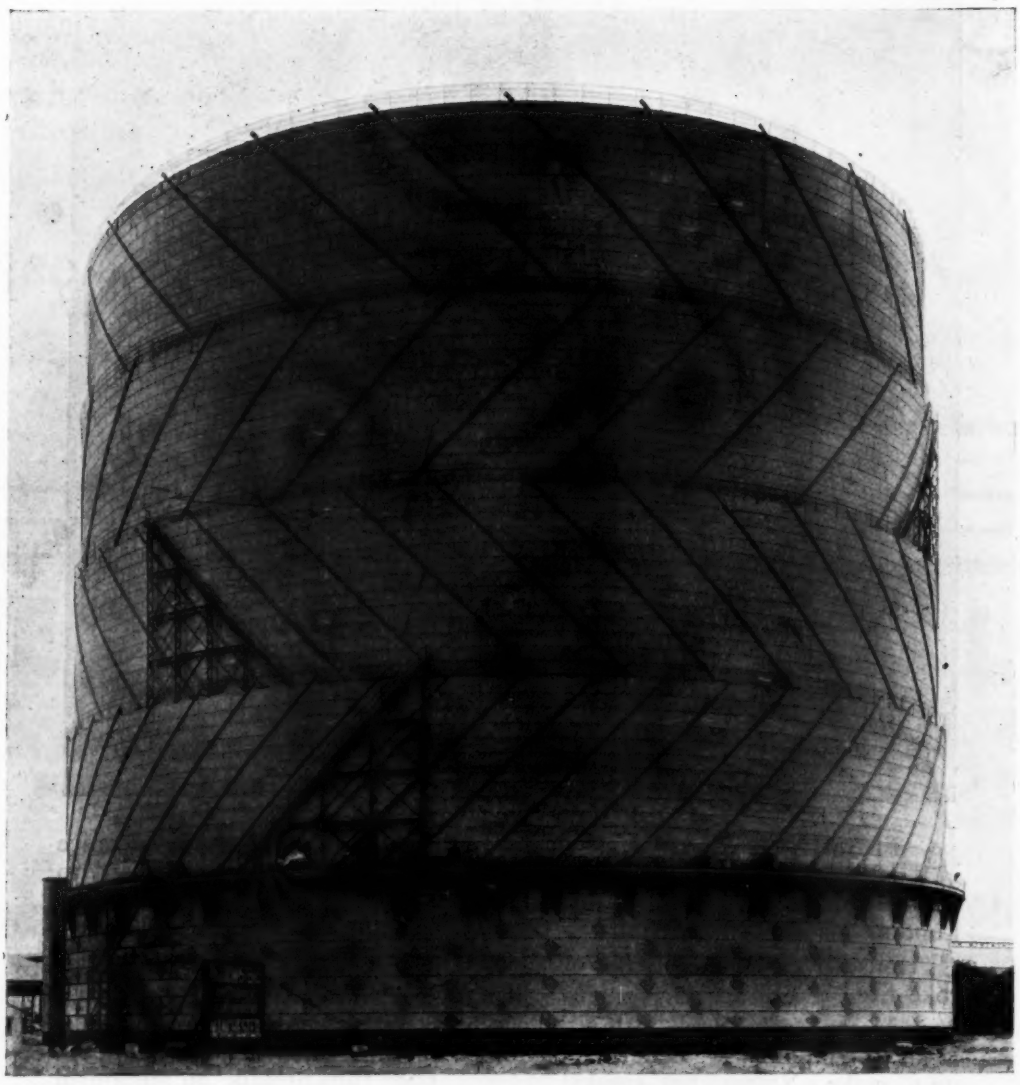
Housewives speak highly of the labour-saving value of a "Metro" coke fire!

"Metro" coke fires burn ordinary, broken gas-works coke. The coke is easily ignited by a gas burner contained in the grate, and quickly burns up to make a flaming hot, smokeless fire. They thus provide an additional outlet for coke in the home market, and a useful gas load. "Metro" coke fires are standardised appliances, easily fitted, and require little maintenance. They are made by Sidney Flavel & Co., Ltd., of Leamington, who will gladly forward illustrated price lists on request. Gas Engineers will be cordially welcomed at the London Showrooms: 38, Welbeck Street, W.1, where "Metro" coke fires can be seen burning under everyday conditions.

COKE FIRES BURN COKE THE BETTER WAY

"Metro" coke fires are manufactured and distributed for the South Metropolitan Gas Company by Sidney Flavel & Co., Ltd., Leamington

R. & J.
DEMPSTER
GAS & CHEMICAL ENGINEERS
LONDON OFFICE: 34 VICTORIA ST. S.W.1.
LTD.



VIEW SHOWING 5,000,000 SPIRAL HOLDER IN STEEL TANK.
R. & J. D. HAVE ERECTED THE LARGEST SPIRALLY GUIDED GASHOLDER.

GAS · PLANT · WORKS
MANCHESTER

PHONE: MANCHESTER COLLYHURST 2554
WIRE: "SCRUBBER" MANCHESTER

R. & J
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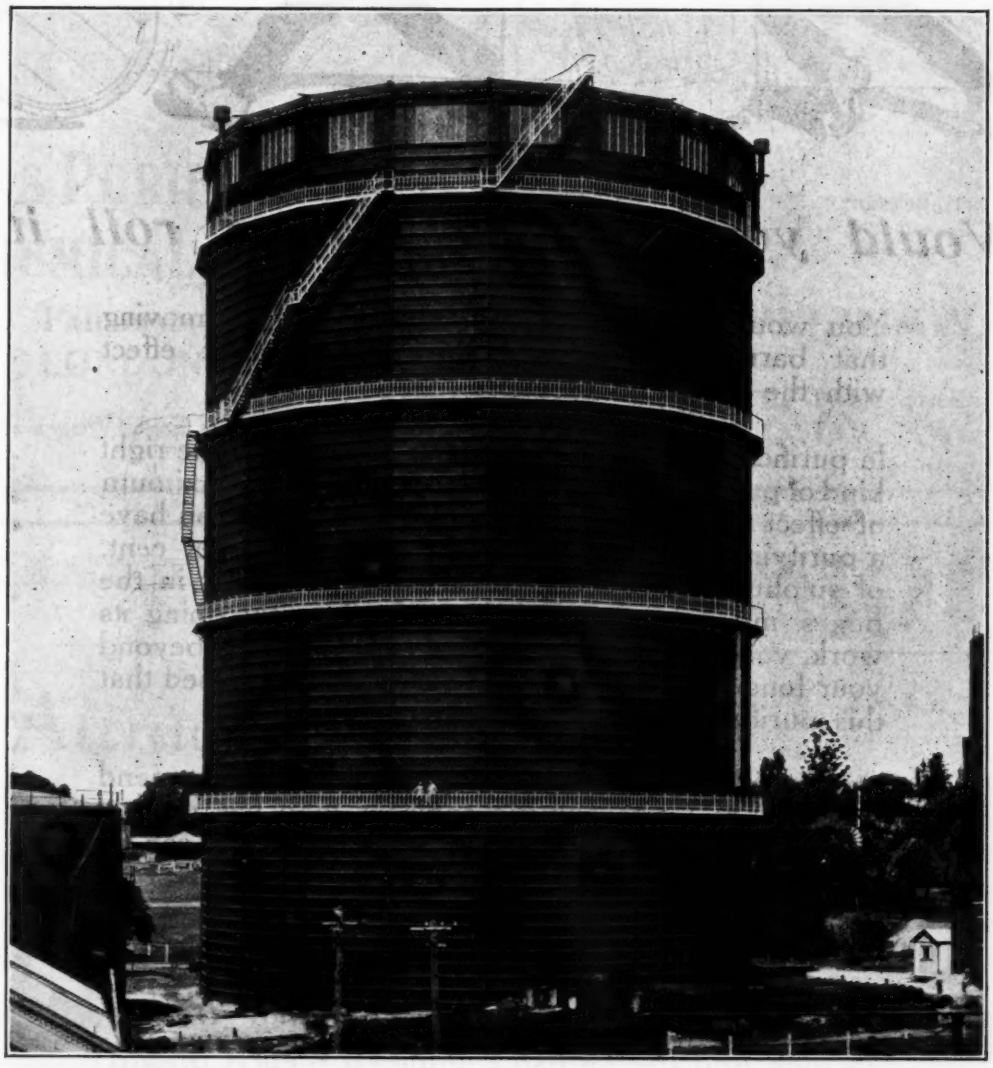
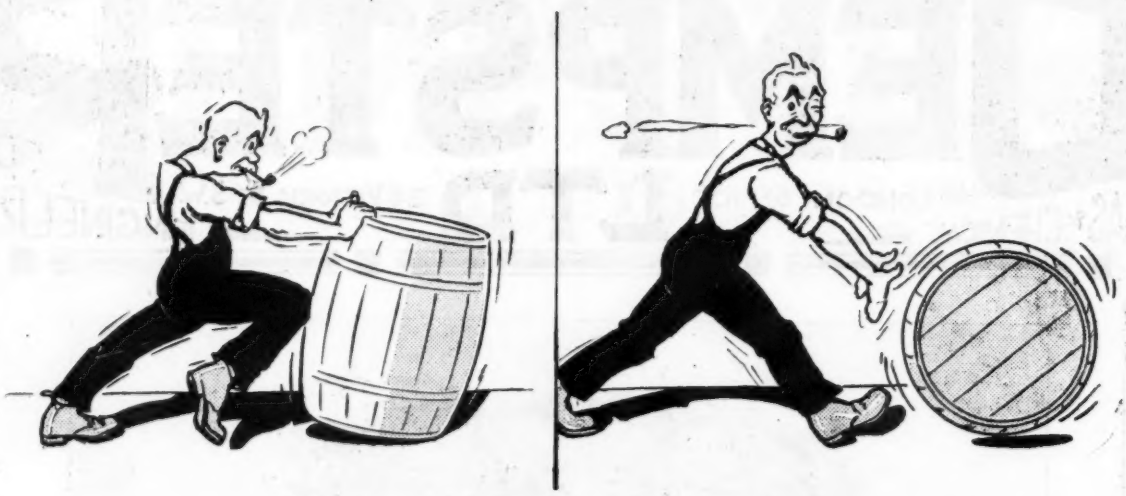
GAS & CHEMICAL ENGINEERS
LONDON OFFICE: LTD. 34 VICTORIA ST. S.W.1.



VIEW SHOWING THE ATTRACTIVENESS OF A "WATERLESS" GASHOLDER, SUITABLY PAINTED AFTER COMPLETION.

GAS · PLANT · WORKS
MANCHESTER
PHONE: MANCHESTER COLLYHURST 2554
WIRE: "SCRUBBER, MANCHESTER"



Would you push it . . or roll it?

You would certainly try the easier way of moving that barrel, and so gain the maximum of effect with the minimum of effort.

In purification matters everything depends on the right kind of purifying material. You can have the maximum of effect with the minimum of trouble. You can have a purifying material which will take up to 60 per cent. of sulphur, and because you are able to leave it in the boxes much longer, quietly and efficiently doing its work, you will find your labour costs reduced beyond your fondest anticipation. You will have guessed that this purifying material is "LUX."

"LUX" has every quality that should recommend it to any gas engineer who has not yet used it, and to all our expert advice about it can be sought without any obligation.

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See also under "Notices to Correspondents," &c.

THE

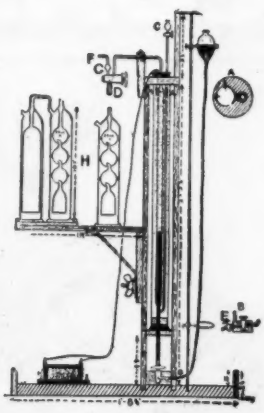
Buckley-Sinnatt Gas Analysis Apparatus

(See "GAS JOURNAL," Nov. 4th, 1919.)

Pamphlets on Application.

Improved type with all glass parts of standard size so that they can be replaced at any time.

PRICE: £12 (Complete with Teak stand and Sliding Shelf, without Coil and Accumulator).



SPECIALITIES:

GAS ANALYSIS APPARATUS
(Original maker of the Bone & Wheeler Gas Analysis Apparatus.)

(See "Fuel in Science and Practice," July, 1924.)

(*Pamphlets on Application.*)

PRICE: £26 15s. (complete with Teak Stand without Accumulator and Coil).

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for Technical and Scientific Use.

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University Works, 42, Bridge Street, C.-on-M., MANCHESTER, S.W.

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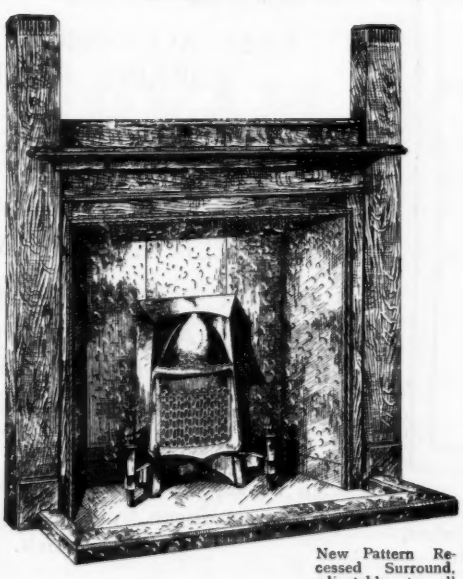
Attractive Surrounds



New Pattern Recessed Surround, adjustable to all mantel openings; Hearth Plate and Curb to match.

that will increase Gas Fire Sales

The beautiful, artistic designs, the many distinctive finishes, the fact that they are easily adjustable to fit all mantel openings, and their moderate prices, are features that account for the popularity and increasing demand of

Turner's Art Metal Surrounds.

Display them prominently in your Showrooms.

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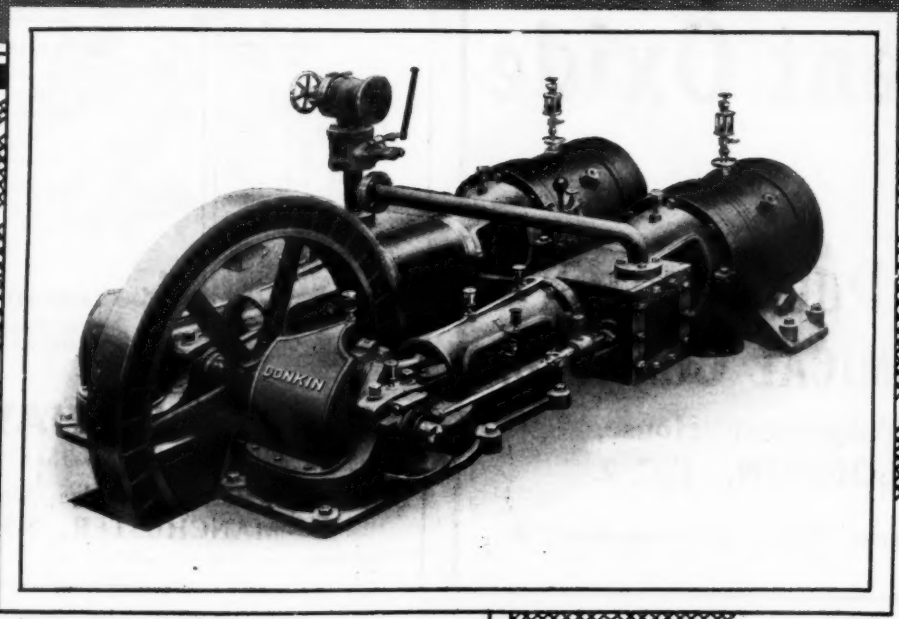
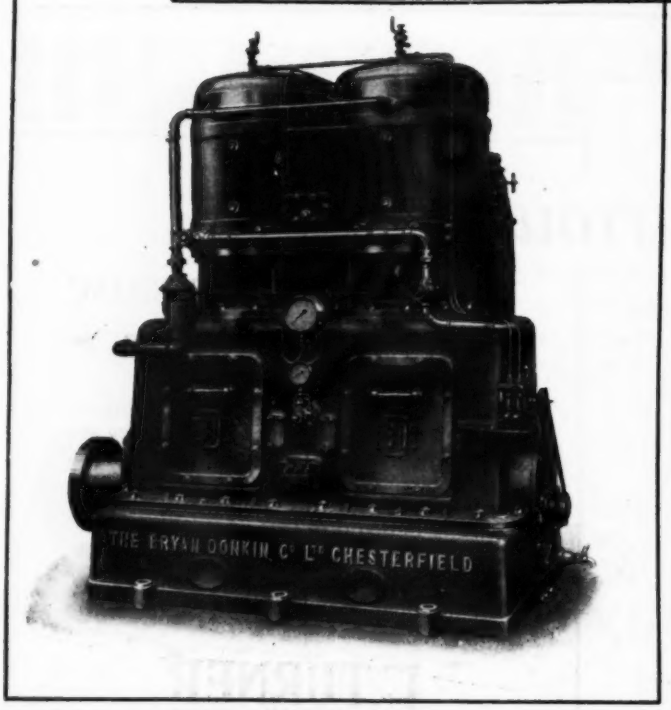
'Phone: Central 0704. *'Grams: "Artistique ('Phone), Birmingham."*

DONKIN RECIPROCATING GAS COMPRESSORS



Horizontal Duplex Type, Steam Driven



Vertical High Speed Duplex type, fitted with forced lubrication to all bearings—one common inlet and outlet branch for both cylinders, Perfect balance, ensuring absence of vibration at high speeds.

FOR PRESSURES UP TO 100 LBS. PER SQ. INCH

AUTOMATIC CONTROL OPERATED BY GAS PRESSURE

EASY ACCESSIBILITY TO WORKING PARTS

ROBUST CONSTRUCTION, AND OF THE VERY LATEST DESIGN

AUTOMATIC SUCTION AND DELIVERY VALVES

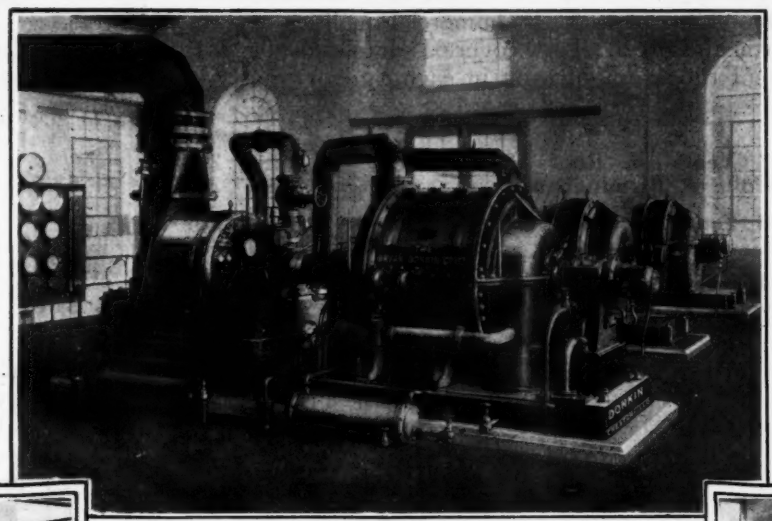
BEARINGS AND ALL WORKING PARTS OF AMPLE PROPORTIONS, GIVING ABSENCE OF WEAR AND ENSURING LONG LIFE

Can be supplied as a Steam-driven Compressor, or driven by Gas Engine, Electric Motor or Belt.

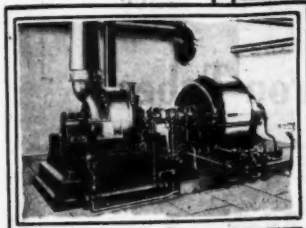
THE BRYAN DONKIN COMPANY, LTD., CHESTERFIELD

RATEAU TURBO GAS COMPRESSORS EXHAUSTERS AND BLOWERS

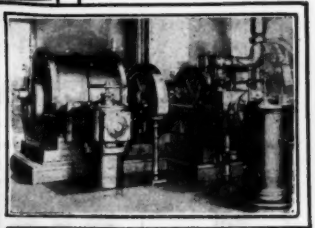
DRIVEN BY STEAM TURBINE, GAS ENGINE, ELECTRIC MOTOR OR BELT.



A Rateau 5-stage Turbo Gas Compressor capable of passing 500,000 cubic feet per hour against 10 lbs. per sq. in. outlet pressure at 3,900 R.P.M., driven by a 450 B.H.P. Steam Turbine. Also 2 Steam Driven Rateau 2-stage Turbo Exhausters, each capable of passing 500,000 cubic feet of gas per hour at 3,000 R.P.M.

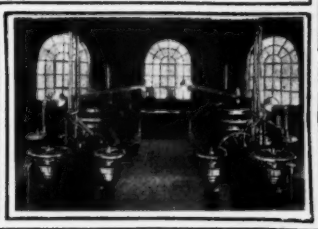


Rateau 3-stage Turbo-Exhauster to pass 500,000 cubic feet per hour at 3,250 R.P.M., driven by Steam Turbine.



Gas Exhauster driven by Steam Engine, to pass 125,000 cubic feet per hour.

Kiosk housing a District Gas Governor.



Installation of Reynolds' Patent District Governors, reducing Gas pressure from 15 lbs. per sq. in. to the normal supply pressure.

THE BRYAN DONKIN CO. LTD.

CHESTERFIELD, ENGLAND.

ALSO MAKERS OF

GAS EXHAUSTING PLANTS
for large and small capacities.

ROTARY BLOWERS and COMPRESSORS
of positive type for industrial purposes.

RECIPROCATING GAS COMPRESSORS,
vertical and horizontal types.

GAS VALVES of ALL TYPES and SIZES
(air and gas), and for high and low pressures.

PATENT DISTRICT GAS GOVERNORS
for reducing any inlet pressure up to 50 lbs., down to ordinary district pressure.

KIOSKS for housing gas governors.

HIGH and LOW PRESSURE GAS REGULATORS
for gas services, meters, gas fires and stoves.

DOUBLE FACED GAS VALVES.

SUB-SOIL VENTILATOR BOXES for detecting gas leaks and for road ventilation.

Associated Company: BRITISH FURNACES, LTD.
Makers of Industrial Furnaces.

CORROSION TESTS

THE following figures, published in the Iron and Steel Institute Carnegie Scholarship Memoirs Vol. XVIII., 1929, represent the final results of seven years of research carried out to determine the relative corrodibility of various commercial qualities of Wrought Iron and Steel. They cover 64 samples in all, and represent the average result in each category :—

		Loss of weight (grammes)	*Per cent. diff.*
7 Years on Roof of Technical College, Birmingham	**Iron**	**201·2**	
	Steel	**309·0**	**+ 53·5**
6 Years on Roof at Birmingham Gas Works	**Iron**	**207·4**	
	Steel	**353·9**	**+ 70·16**
4 years exposed to air and sea-water at Weston-super-Mare	**Iron**	**137·3**	
	Steel	**179·8**	**+ 31·0**

IT is obvious that in the case of thin metal products such as tubes, a Steel Tube will rust away long before a Wrought Iron one. Think what this may cost at the end of a few years in renewals, especially where labour and transport charges are heavy.

It is Cheaper and Safer to Use Wrought Iron Tubes

THE BARROWFIELD IRON WORKS, LTD.,

GAS ENGINEERS AND CONTRACTORS,

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Phone: CENTRAL 2798

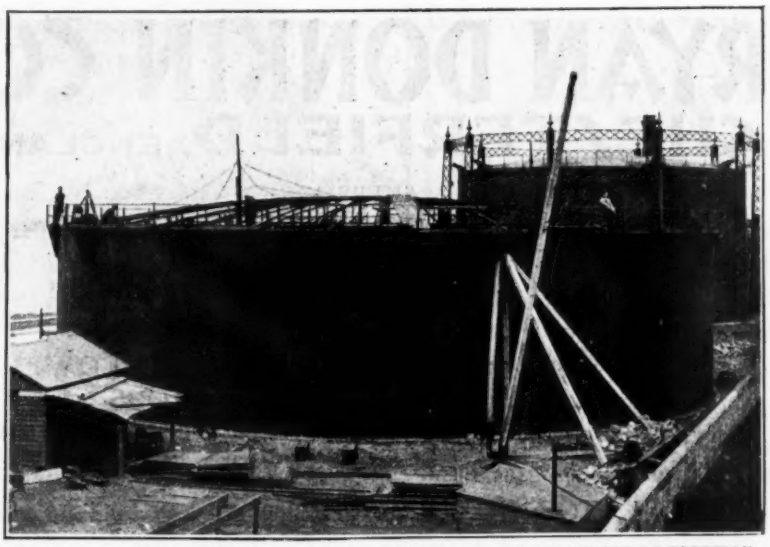
GLASGOW.

GASHOLDERS and TANKS of any size or type.

CONDENSERS: Water Tube, Annular or Open Atmospheric.

TOWER SCRUBBERS.

PURIFIERS: Water or Dry Lute Cast Iron or Ferro Concrete Boxes.



TELESCOPIC SPIRAL GASHOLDER IN STEEL TANK, 102 FT. DIA., IN COURSE OF ERECTION

OIL and CHEMICAL WORKS PLANT.

STRUCTURAL WORK of every description.

STEEL RIVETTED PIPES.

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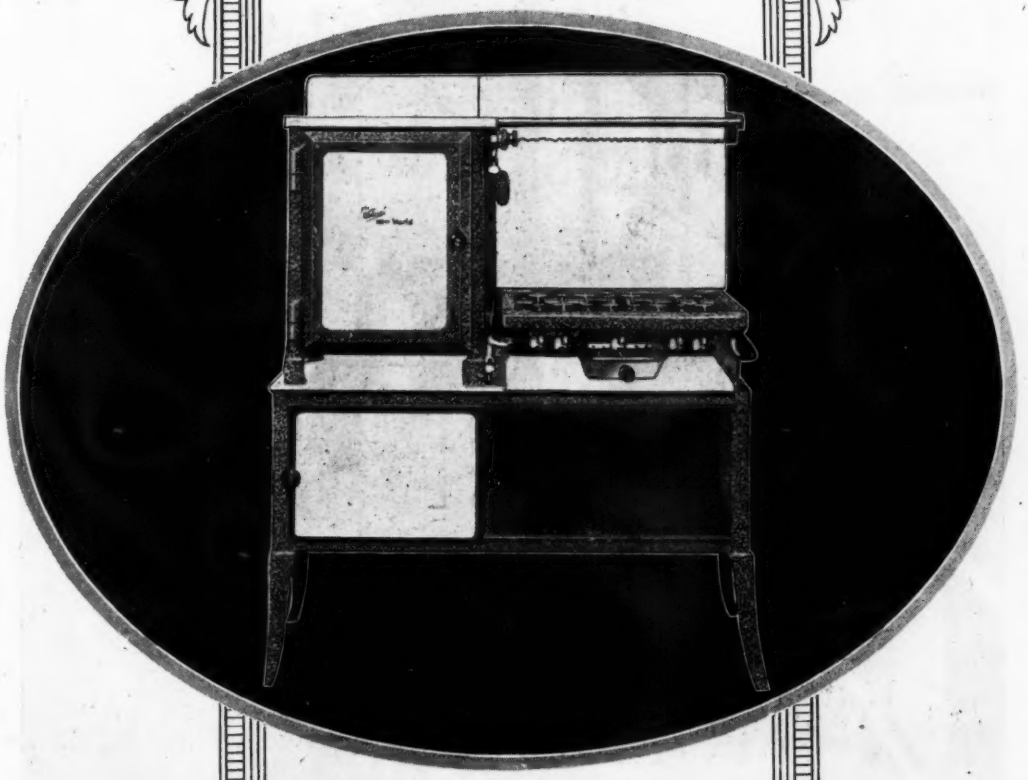
EYE LEVEL

This popular cooking range has both oven and hotplate at the most convenient level for easy working, without the necessity for stooping. The warming closet is roomy, separately heated, and has a convenient sliding door. The boiling burners are of the high-efficiency type, and the range is finished in "Rado" porcelain enamel, glass-hard and cleaned in a few moments.

Send for illustrated lists.



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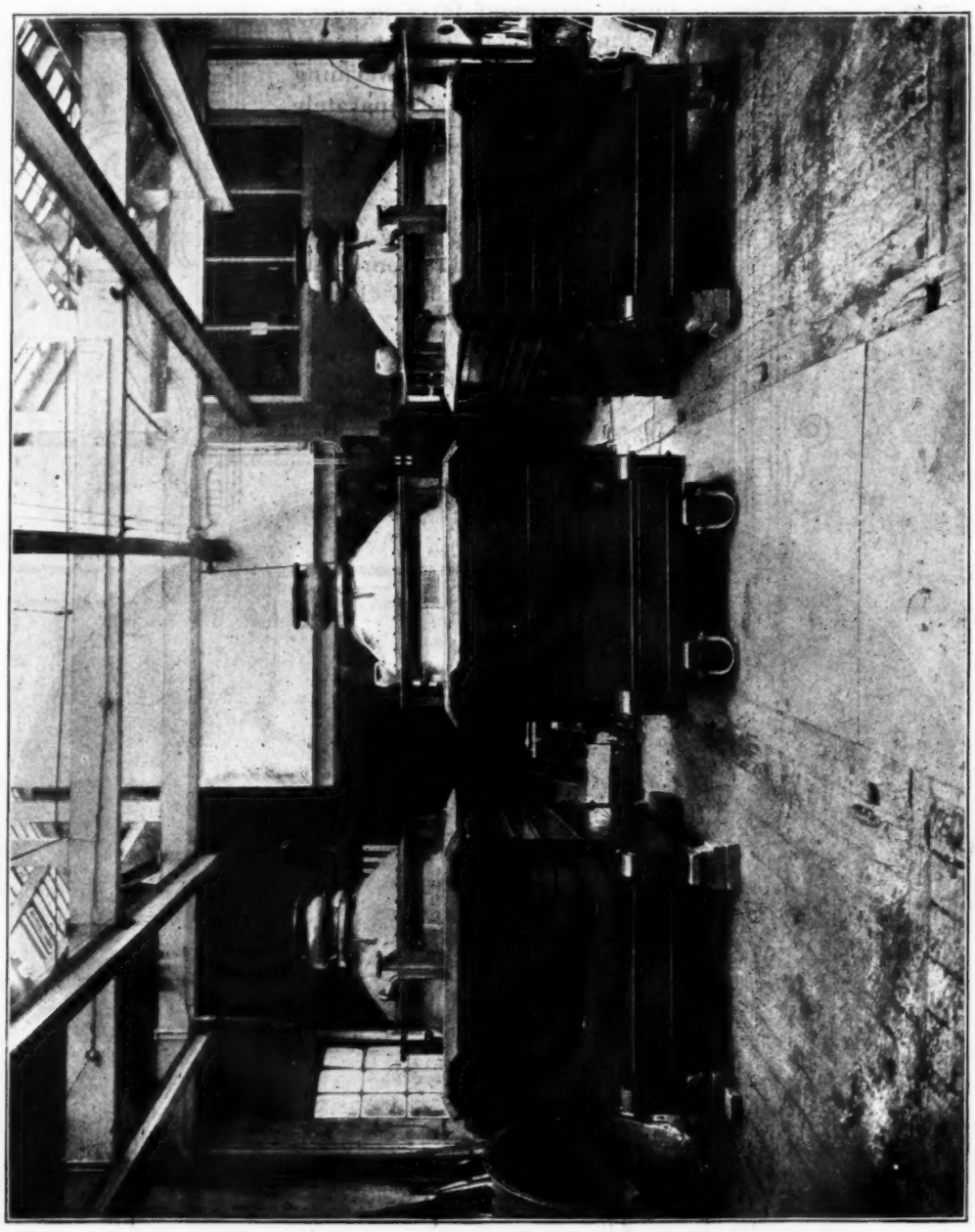
SATURATORS

And all Leadwork for Sulphate of Ammonia Plants

OVER 824 SATURATORS SUPPLIED



Photograph taken February, 1930, showing our latest make of Saturator. The Three shown were recently delivered to BELGIUM.

JOSEPH TAYLOR (Saturators) Ltd.

Blackhorse Street Mills, BOLTON

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for all heating operations

Are you satisfied with the sale of your Gas for industrial purposes?

You must increase the output of your works by selling Gas and keeping it sold.

We can help you by making in conjunction with yourselves an industrial survey of your district. Our trained Engineers can analyse all the different heating operations and advise and solve problems as to the best and most economical type of furnace to be used.

Your objective is to supply all the heating requirements in your district and to prove that what is done with heat can be done best with gas.

Let us help you

We give 8 classes of service

1. Fuel surveys.
2. Plant layouts.
3. Standardised furnaces.
4. Complete furnace designs.
5. Converting existing furnaces.
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7. Supply of stock appliances.
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With our SURFACE COMBUSTION equipment there are:

Greatly reduced fuel costs.
Increased daily output.
Reduced labour cost.
Lower operating cost.
Improvement in quality of the product.

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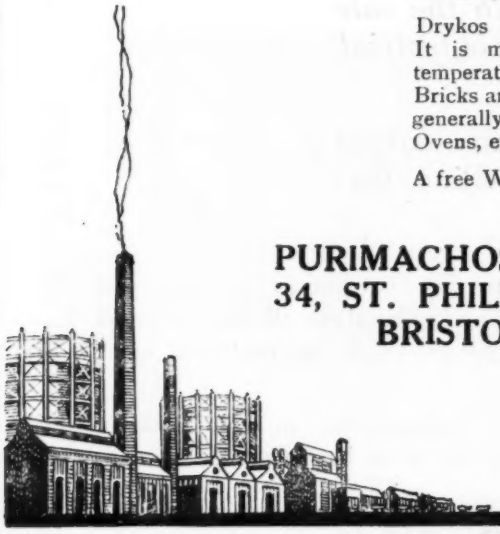
THE STANDARD FIRE CEMENTS....

Purimachos Plastic Fire Cement needs no introduction. Its reputation of nearly 50 years as a Patching Cement speaks for itself.

Drykos Dry Fire Cement is a perfect Fire Cement in Powder Form. It is manufactured in several Grades suitable for medium or high temperatures. Our H.3 Grade is recommended for Silica Retorts and Bricks and for high temperature work generally. The Standard Grade is generally preferred for Fireclay Retorts, Gas Producers, By-product Ovens, etc.

A free Working Sample will be sent willingly on request.



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34, ST. PHILIP'S,
BRISTOL.

Drykos
Dry Fire Cement (Regd)

STEEL FOR STRENGTH

Steel Mains will not break under the loads imposed by modern traffic nor under the stresses due to movements of the ground.

STEWARTS AND LLOYDS LTD.

GLASGOW BIRMINGHAM LONDON

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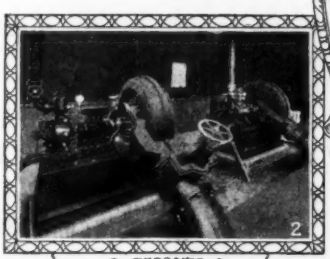
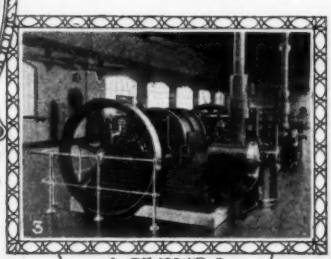
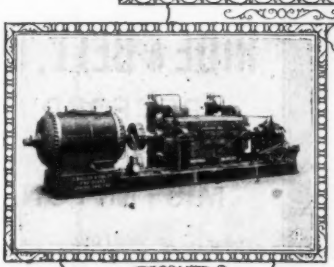
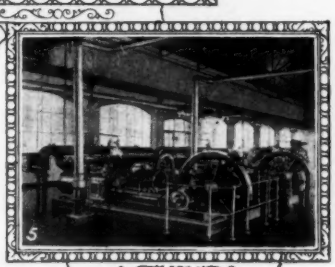
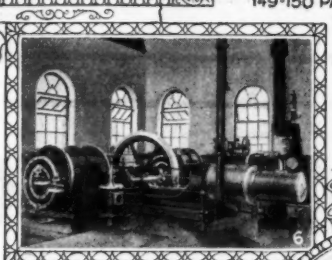
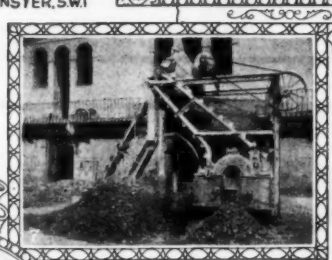
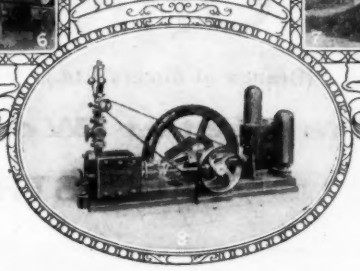

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Phœnix Iron Works

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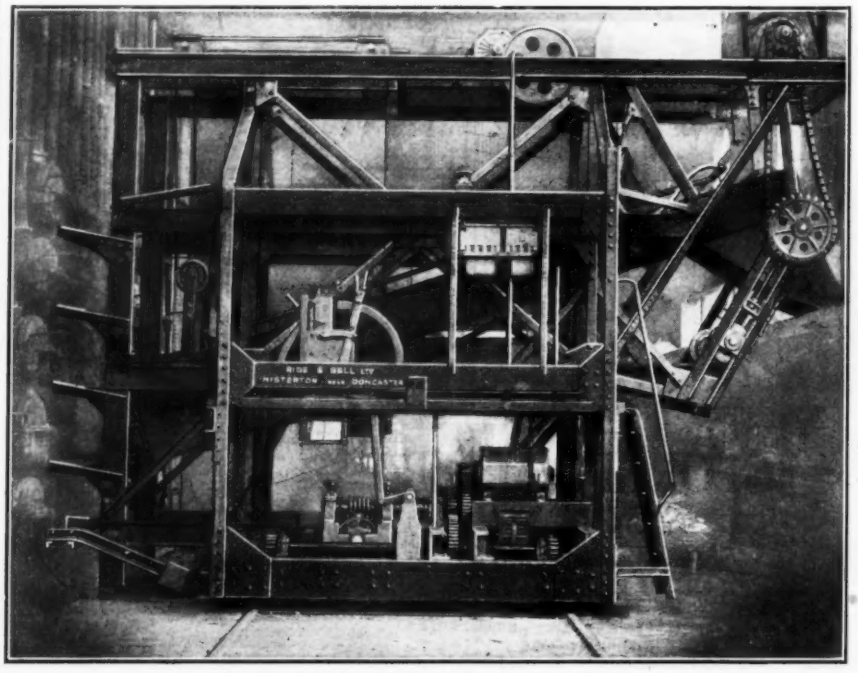

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ARRANGED FOR 1d., 6d., 1s., OR ANY OTHER COIN DESIRED.

These Meters are giving Universal Satisfaction wherever adopted.

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One of the Most Efficient Prepayment Meters Yet Designed.

Engineers are invited to test the

"DOUGALL" DESIGN AUTOMATIC METER

It embodies a simple

TWO-COIN DEVICE

which can be changed in an instant from **1d.** to **1/-** or vice versa.

Valve opens at 5 cubic feet without the aid of a spring.

DOUGALL'S METERS prevent fraud. They cannot be pumped for free gas.

Large Cash Box.

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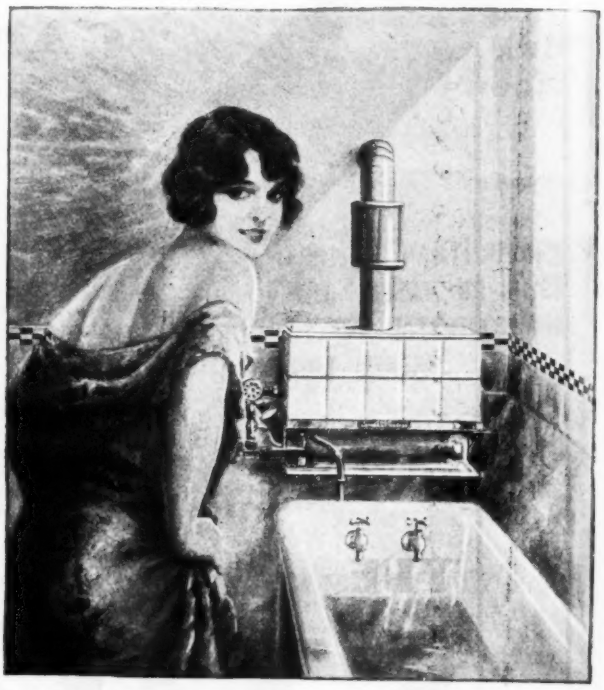
Easily - Quickly - Cheaply



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WITH THEIR CHARACTERISTIC "WHITE TILE" APPEARANCE

Every line of their design speaks of simplicity, of compactness, of long life, and their attractive "WHITE TILE" appearance harmonizes readily with any scheme of decoration. All models are fitted with "Chromettic" Plated Fittings, meeting the modern demand—labour saving.

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"ACME NEW WORLD"
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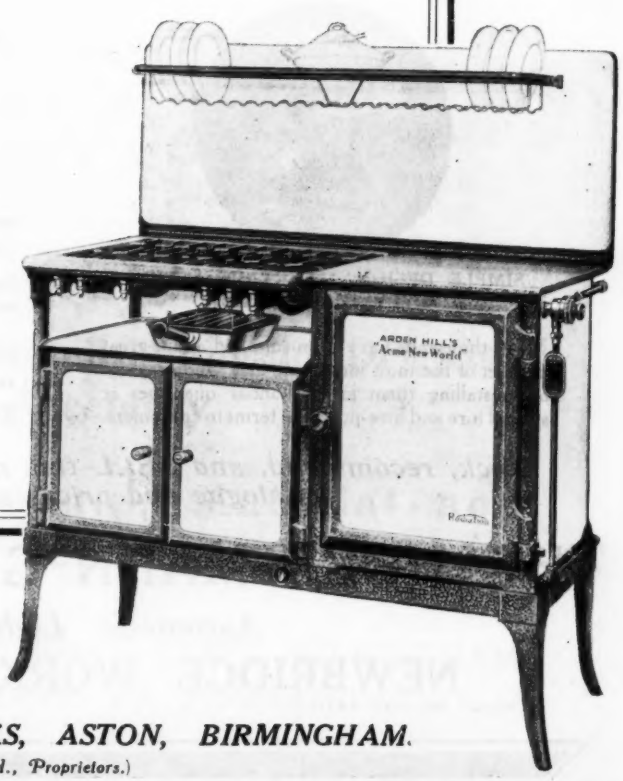

The R.H.D. 166 "Acme New World" Gas Range in "Rado" Mottled Enamel Finish.

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TYPE 3A/UNI—15 DAY RUN.

Quick lighting and extinguishing.
Extinguishing pilot to order.
Instantly detachable and guaranteed interchangeable clockwork movements.
Lubricator to the gas cock.
Gas cock guaranteed for 10 years against sticking or leaking.

TYPE 15/3A—15 DAY RUN.

Quick lighting and extinguishing.
Only 5½" long overall.
For suspension or upright harp lamps.
Clockwork movement instantly detachable.
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The clockwork movements fitted to NEWBRIDGE gas controllers are products of the highest quality, BRITISH MADE at our works at Bath, save the Swiss double roller lever platform escapements, fully jewelled with rubies and sapphires only. They embody many features specially adapted for the work they are called upon to perform and their simple but ingenious design ensures commercially correct timekeeping. They are extraordinarily robust and very simple to wind and adjust—a disabled lamp attendant *with the use of only one hand* winds and adjusts a round of 200 Newbridge controllers (name of Authority upon request).

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Many thousands have been supplied and a great number of the most important Gas Undertakings are installing them in substantial quantities at special hire and hire-purchase terms to consumers.

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POSITIVE DISTANCE
GAS SWITCHES

make gas as convenient as electricity for indoor lighting, with the added advantage that *lights may be dimmed.*

Supplied with cable in standard lengths of 6, 9, 12, 18, 24, 36, and 48 ft.

Flush hand controls and duplex sets for two-way switching are available at a slight extra cost.

The finest insurance for your lighting load.

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Automatic Lighting Engineers,

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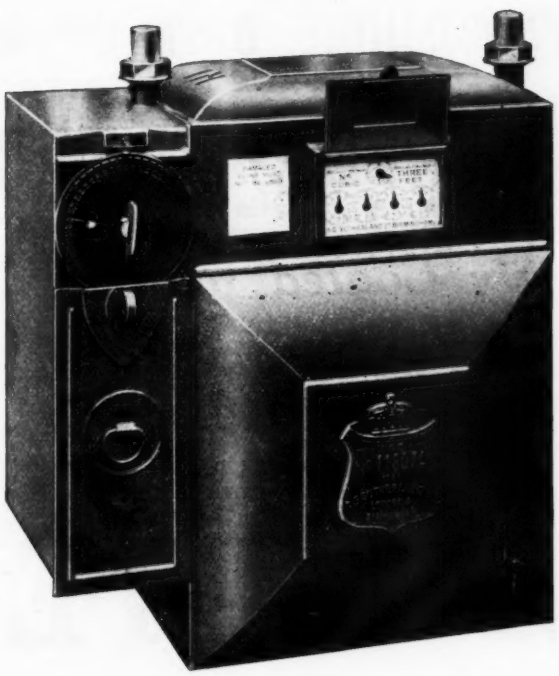

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ORDINARY METERS
PREPAYMENT METERS
HIGH CAPACITY METERS
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General Repairs and Reconditioning of Dry Gas Meters a Speciality

First-class Workmanship, Material and Prompt Service

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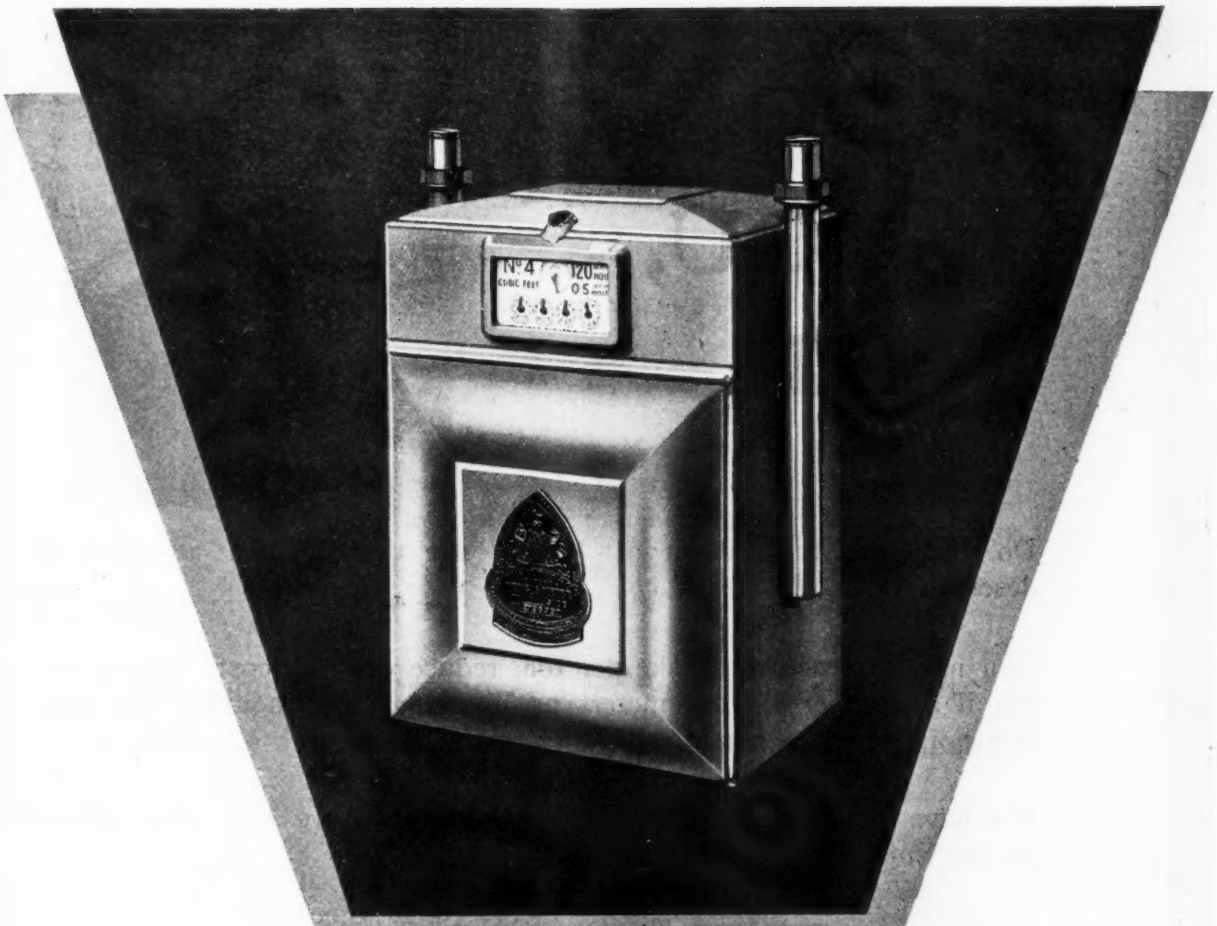

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Do you give the subject of Meters the thought and attention it deserves?

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We have made Gas Meters since 1850 and if we may offer advice on the subject, we would say:—

Firstly

Instal only the best British meters they are least expensive in the long run.

NOTE

There is no **better** meter than the "A. & M." on the market to-day.

80 ft. High Capacity Disc-Change P P.

The Cost of a meter is represented not by its initial price, but by the years of accurate service it gives.

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Keep in touch with your meters in service; test them periodically in situ and weed out defaulters before the "unaccounted-for" figure appals you.

NOTE

With an "A. & M." Portable Dry Test Meter, meters can be tested in situ with a minimum of inconvenience to consumers.

Thirdly

When meters do require attention, send them to a dependable Firm in whom you have complete confidence.

NOTE

Every meter sent to "A. & M." for repair receives that characteristic attention to detail for which we are noted. Where new diaphragms are not considered essential, the old ones are treated *inside and out* with our special mixture.

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"LIGHTS,"
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ACCURATE. RELIABLE. DURABLE.

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STATION METERS, STATION GOVERNORS, TEST GASHOLDERS, VAPORISERS, RECORDING GAS CALORIMETERS, PRESSURE AND EXHAUST GAUGES, STREET LAMPS, ETC. METER REPAIRS.

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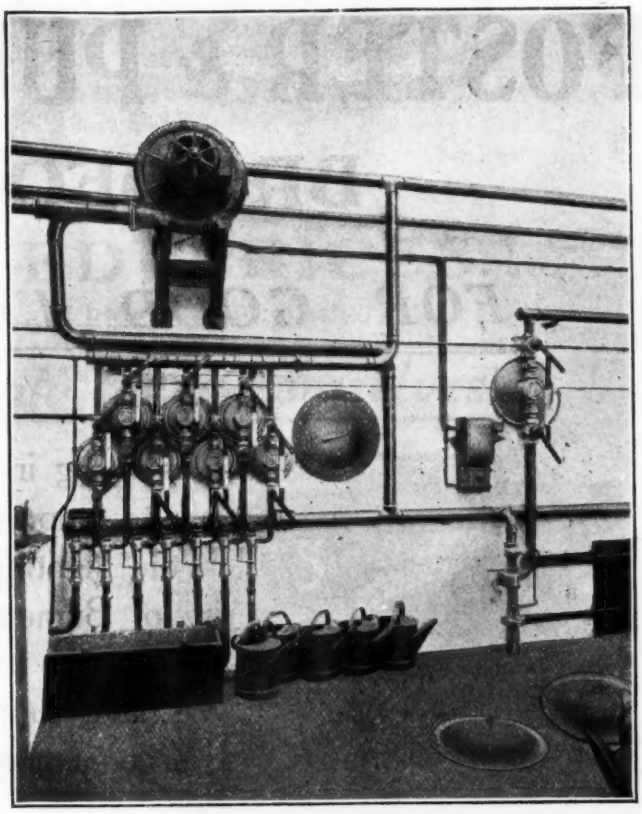
Another victory for Town's Gas!



A WELL-KNOWN Varnish firm some months ago ordered a "Keith-Blackman" Gas Equipment, consisting of Automatic Mixture Control Governors, Injectors, Special Burners and Air Blowing Fan, to convert 16 of their Gum Running Furnaces and Oil Boiling Coppers from solid fuel. This business was secured against competition and after exhaustive tests had been made which proved that it cost only 9½d. per run for our system as compared with 16¼d. per run for the competitive system. After using the plant for six months, clients were so pleased with its efficiency, cleanliness in working and economy in cost of running, that they ordered equipment for converting six additional pots. Part of the first installation is shown in the above photograph.

"KEITH-BLACKMAN" Gas Equipment gives highly satisfactory results when used for any industrial heating process. Are there any carried on in your area which can be done better and more economically by Gas? If so, we shall be pleased to co-operate with you in an endeavour to obtain the business, to our mutual advantage. Our many years' experience and the mass of useful data which we have accumulated, enable us to offer the most efficient and economical solutions.

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Gas Equipment *for* Industrial Heating

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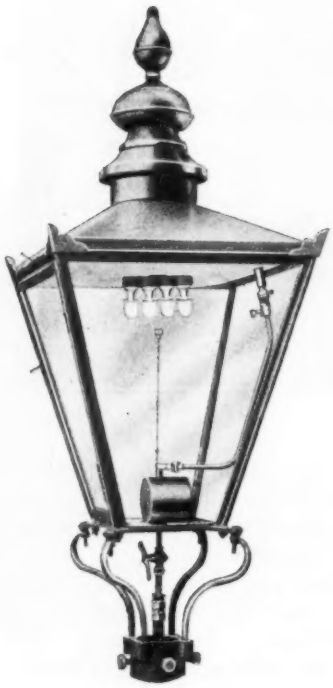
Telephones: Central 7091 to 7097. Telegrams: "James Keith, Phone, London."

FOSTER & PULLEN, LTD.
BRADFORD

FOR GOOD LIGHTING



It is being increasingly realised that a definite improvement can be effected in the lighting of most roads by the use of Burners in alignment.

We have supplied them successfully to a large number of lighting authorities.

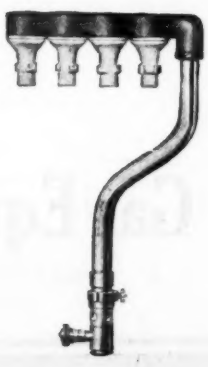
They are also used extensively with Holophane Refracting Plates, which we can supply.

Full particulars on request.

LANTERNS OF VARIOUS SIZES ARE AVAILABLE WITH SUITABLE REFLECTORS FOR ALIGNMENT BURNERS

BURNERS ONLY, TWO TO SIX LIGHT.

ALL BURNERS MAY BE METALLISED TO PREVENT FORMATION OF DEPOSITS



"Supastone"

THREE-PLY GLASS

REDUCED PRICES!

OWING TO INCREASED PRODUCTION

Facts Speak for Themselves!

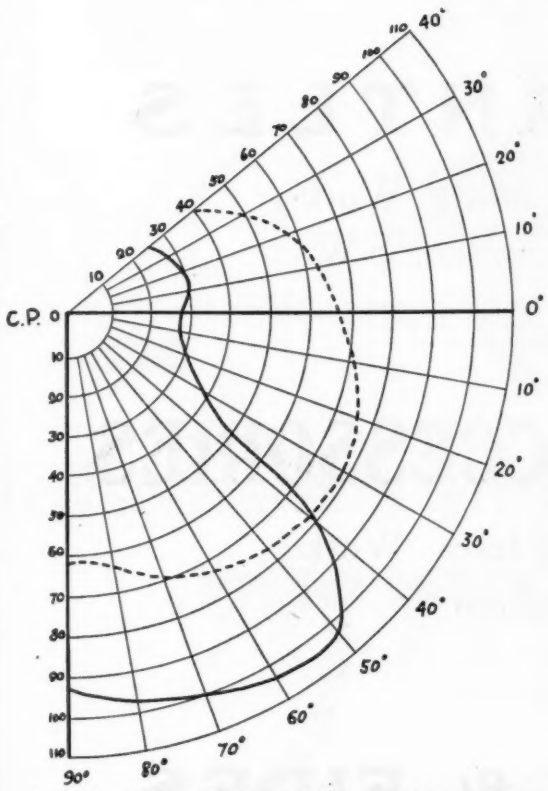
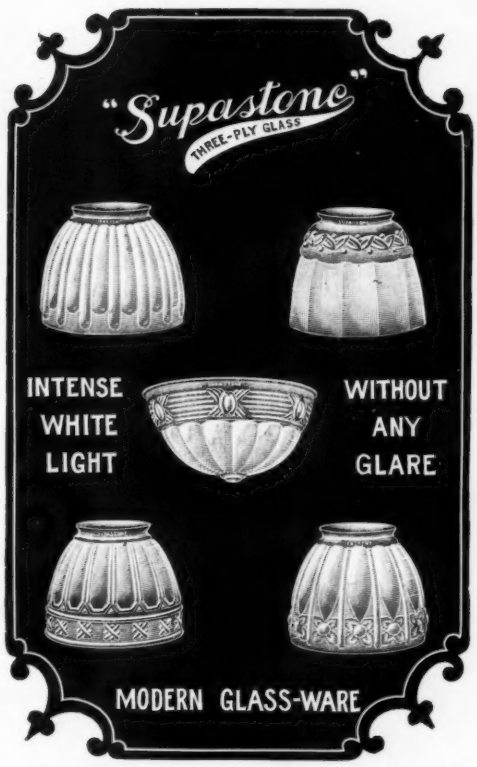


Fig. 143b.—Broken line—Photometric curve of bare mantle. Full line—Photometric curve of mantle and "Supastone" globe.



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A STRIKING TESTIMONY!

Extract from the "GAS SALESMAN."

"'SUPASTONE' is a comparatively new material, and has forged very much to the front recently. This excellent and moderate-priced material is made of three-ply glass—inside clear, centre opal, and exterior satin finish. The common form of plain (general purpose) 'SUPASTONE' globe, intensifies the light at the lower angles—see polar curve, fig. 143b—and gives a mellow, creamy hue to the emerging light, the whole surface of the globe possessing a uniform brightness. 'SUPASTONE' makes a most satisfactory diffusing material."

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ARE **MANUFACTURERS** OF IMPORTANT

GAS LIGHTING, HEATING,
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SUCH AS

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Have your Streets better Lighted

WITH THE

"PARKINSON"

New Series

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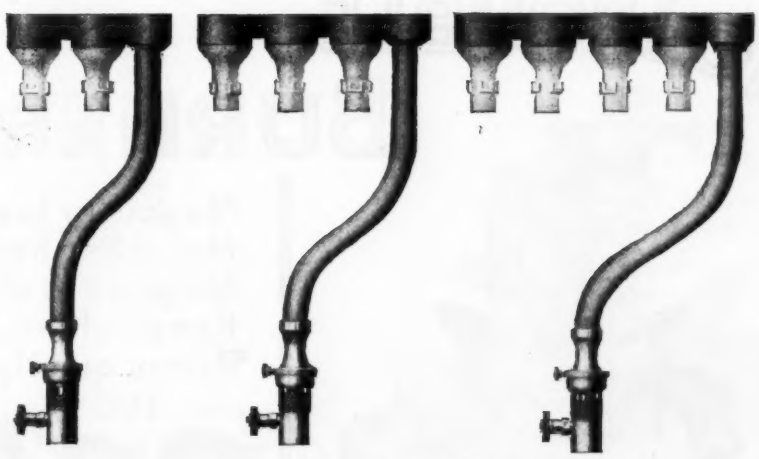
Type "GA"

"700" SERIES Type "GA"

"840B" SERIES
Type "GA"

CONVERSION SETS WITH NOZZLES IN ALIGNMENT



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METALLISED BURNERS are impervious to the effects of corrosion or combustion, ensuring longer service and saving in mantles. *Samples for trial on request.*

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(Incorporated in Parkinson & Cowan (Gas Meters) Ltd.)

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Square Lanterns
Superheater Burners

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A NO-TROUBLE BURNER—

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Keeps clean,
Burns quietly.

THE BRAY 790D BURNER
BRITISH MADE

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An improved quality in warmth

THE adoption of Radiation Gas Fires with the "Beam" radiant offers the following definite advantages—*without any sacrifice of heating power, thermal efficiency or interchangeability:*

1. A "softer" heat, with a sensation of greater comfort is attained.

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SIX PURIFIERS, EACH 50 FT. × 30 FT. × 8 FT., ERECTED AT STOKE-ON-TRENT.

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Years of experience in making Refractory materials are needed to ensure success. But experience alone is not everything.

Quality of the clay for bricks, retorts, furnace lamps and the like is paramount, for how can experience of manufacture apply itself without quality of material. Combined, these two factors ensure to the Gas Manager and Engineer real success.

Records have been established of installations with Leeds Fireclay retorts lasting eight years in continuous use.

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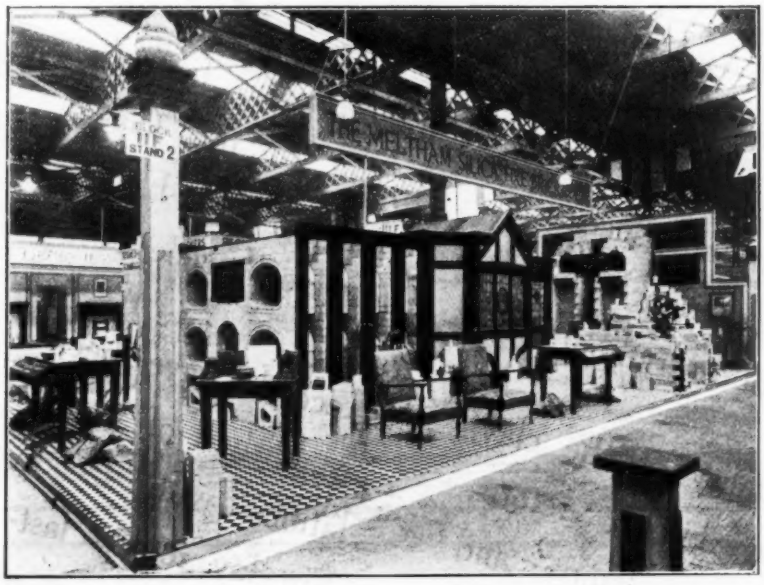

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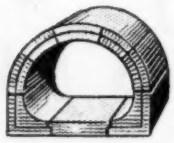
To any Design. ***As Supplied to some of the Largest Works in the Country.***

VERTICAL and SILICA  HORIZONTAL RETORTS

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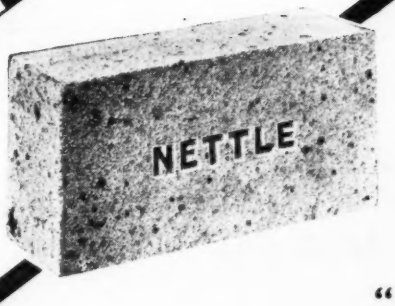

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Acid Washing Test on the Low Boiling Fractions from Coal Tar

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PRICE

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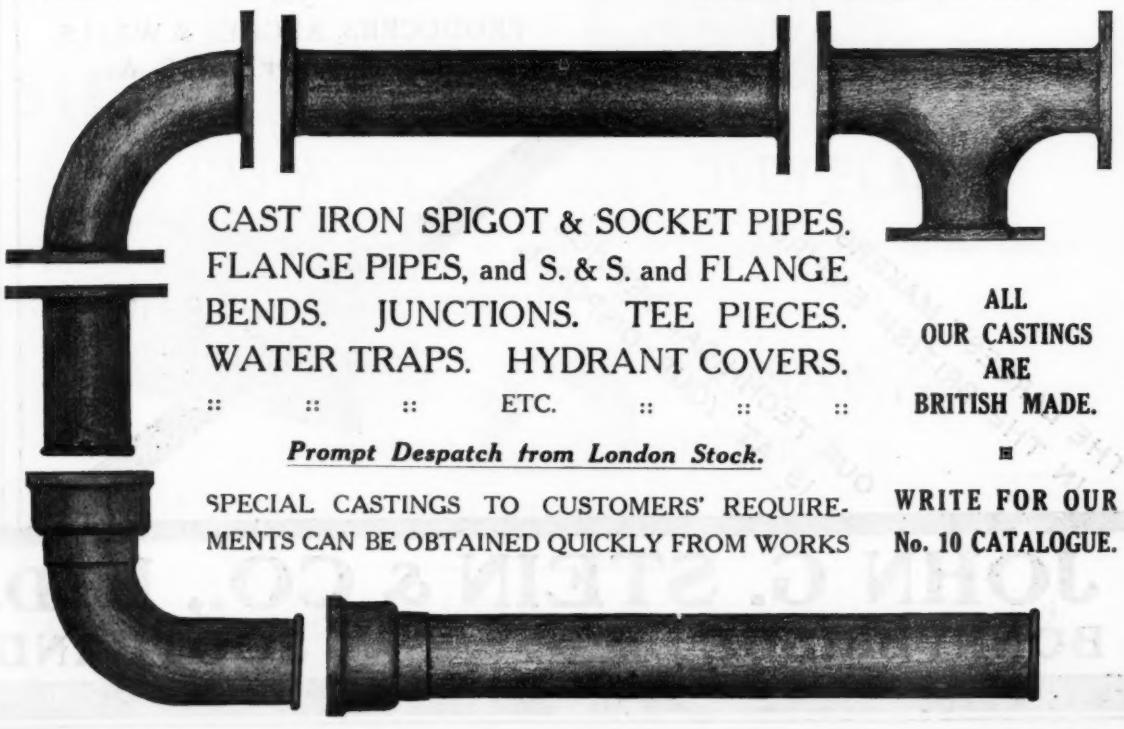

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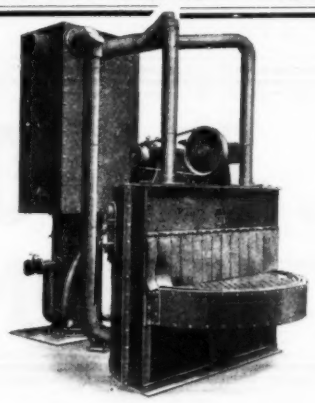

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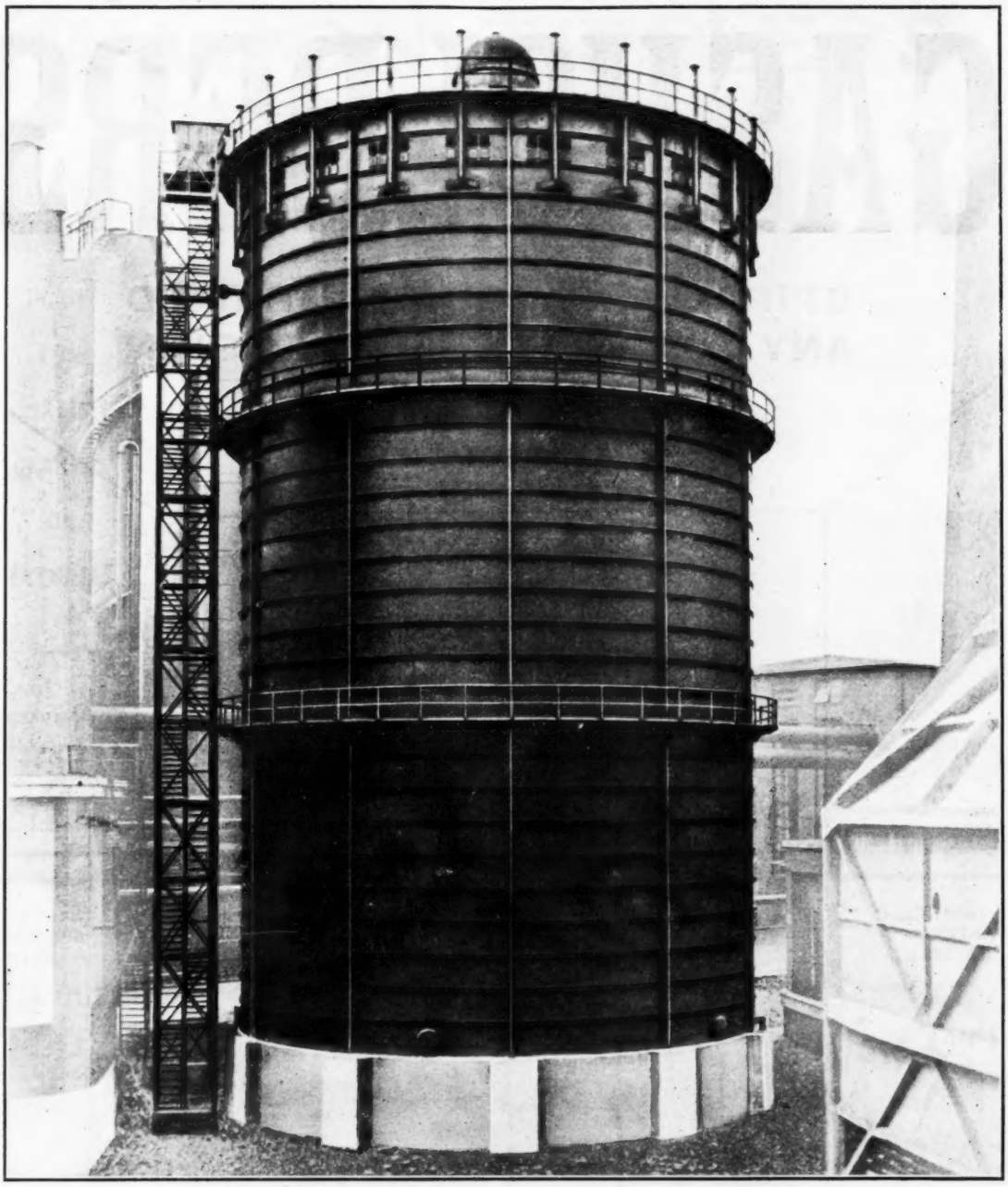

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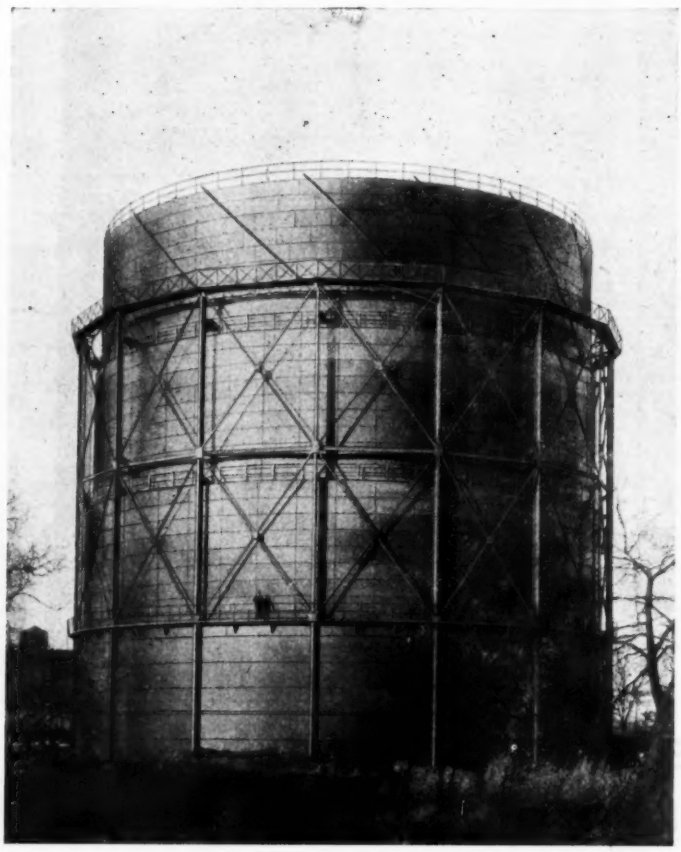

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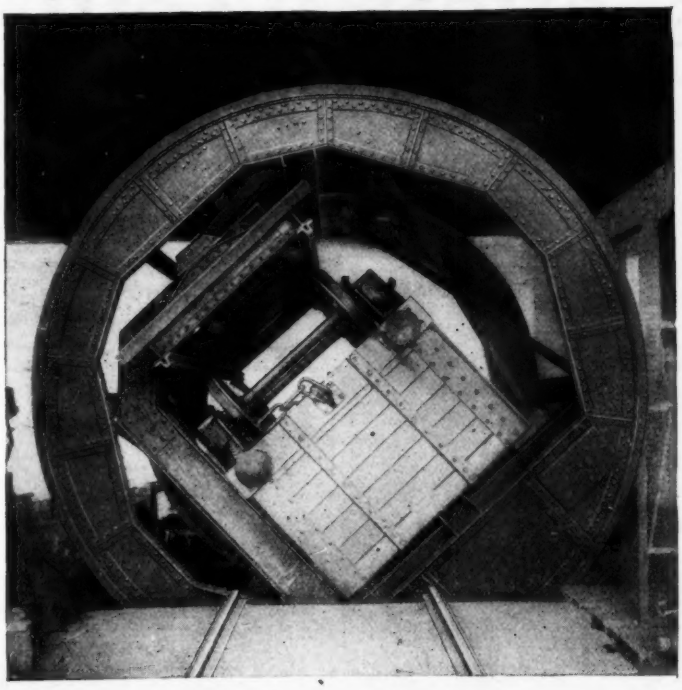

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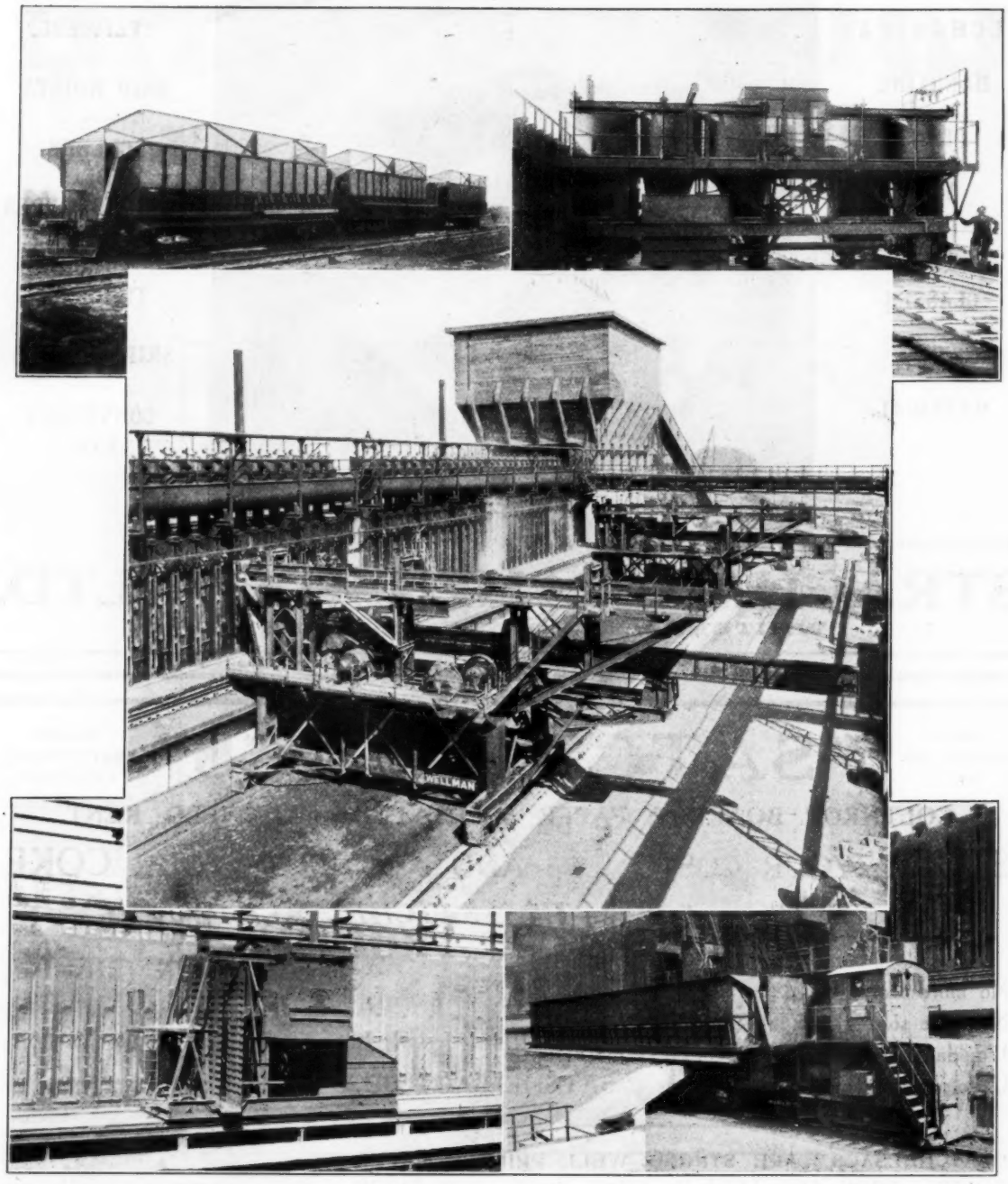

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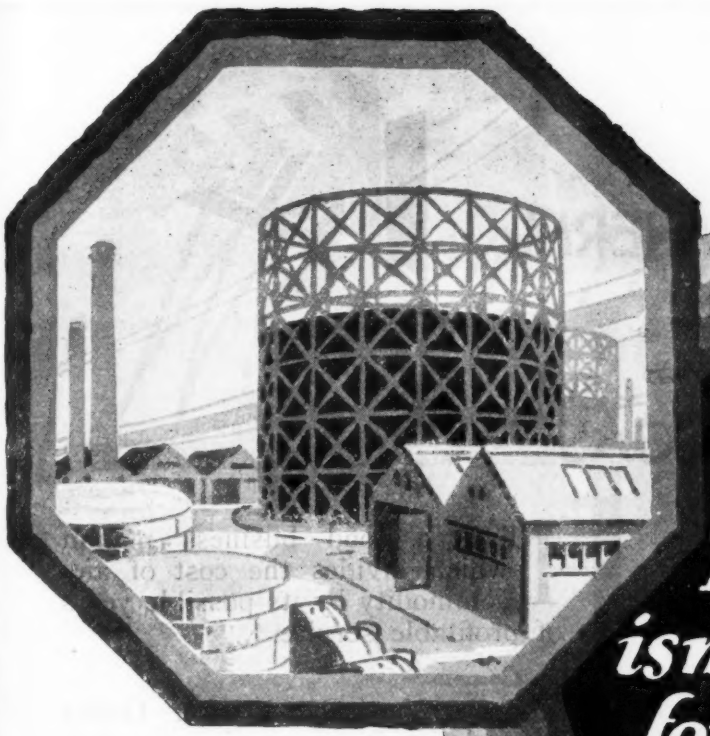

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DEHYDRATE your Tar down to 2% Moisture!

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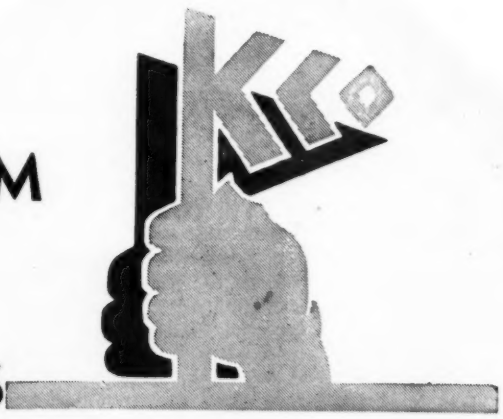

IT is a good business maxim which divides the cost of any commodity by its possible years of profitable service.

Koppers Vertical Chamber Ovens are admittedly expensive in first cost. There are reasons—basic and economic—which amply justify this. By their low maintenance charges, combined with the high quality and quantity of gas produced with low fuel consumption, Koppers Vertical Chamber Ovens actually show pronounced economies over other types of Vertical or Horizontal Gas retorts, even when a generous allowance for depreciation is made upon the capital outlay.

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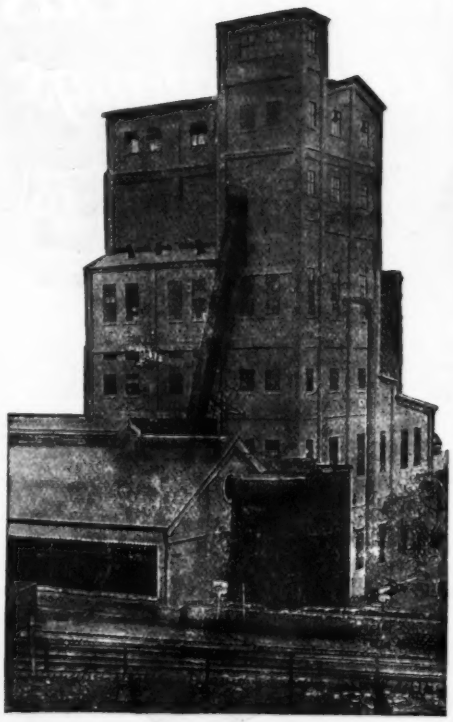

ILLUSTRATION:
Installation of Koppers Continuous Vertical Chamber Ovens at Whaley Bridge

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RECENT developments in the design and methods of construction of the Water Heaters made by the Radiation manufacturers have invested this promising gas field with a new interest.

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"Expamet" Expanded Steel reinforcement is entirely to be relied upon in either skilled or unskilled hands, and the steel goes where it is planned to go without expensive setting out and labour.

The respective meshes "key" into each other, and interlock where sheets overlap; thus a layer of reinforcement may be made absolutely continuous no matter how large the area to be treated.

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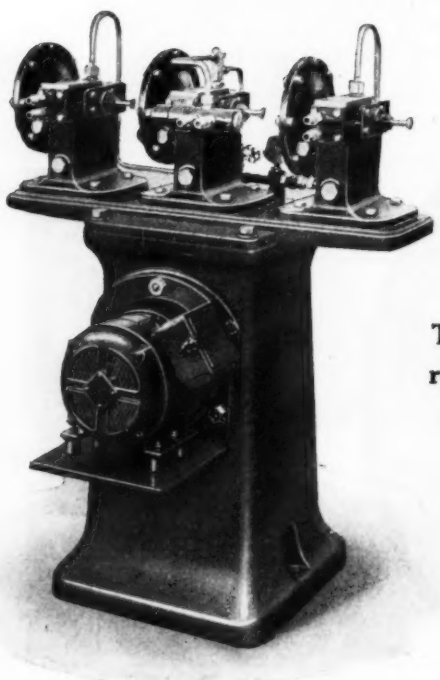

REAVELL ASKANIA REGULATORS.

The plant illustrated is typical of a number recently supplied as Collecting Main and Retort House Governors, Exhauster and Fuel Gas Pressure Regulators for Coal Carbonizing Plant of all types.

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REAVELL & Co., Ltd., RANELAGH WORKS, IPSWICH.

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Gas & Water Under Pressure Specialists

Our Latest Improved Patent Under Pressure
MAIN DRILLING APPARATUS,
fitted with separate automatic and handfeed

The machine is very simple in design. It is made to withstand rough usage.

All working parts are totally enclosed.

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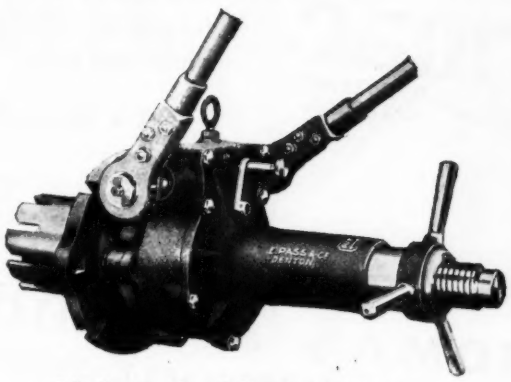

The machine is compact and requires less excavation than other machines.

Drilling time is reduced to a minimum and connections can be made much quicker.

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No. 1 machine to Drill Holes	2"	to	6" dia. inclusive
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An absolutely effective method of taking up drop in mouthpiece lids

Several hundred Mouthpieces have now been installed and are giving every satisfaction.

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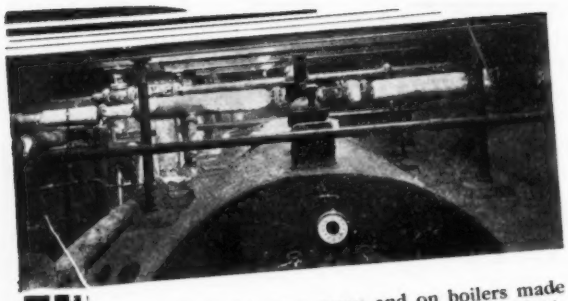

Joints in this pipe range and on boilers made with "Permac," as are gas joints at this plant.

Permac
In Powder Form
JOINTING MATERIAL

Cure all your jointing troubles !

Many of the largest Gas Companies, both in this country and abroad, prefer "Permac" to any other jointing material.

"Permac" is the recognised standard jointing for gas, steam, water and bye-products plant. It is the one material which can be relied upon to make *lasting* leakproof joints to flanged or screwed pipes and tanks.

Get a tin and prove it for yourself.

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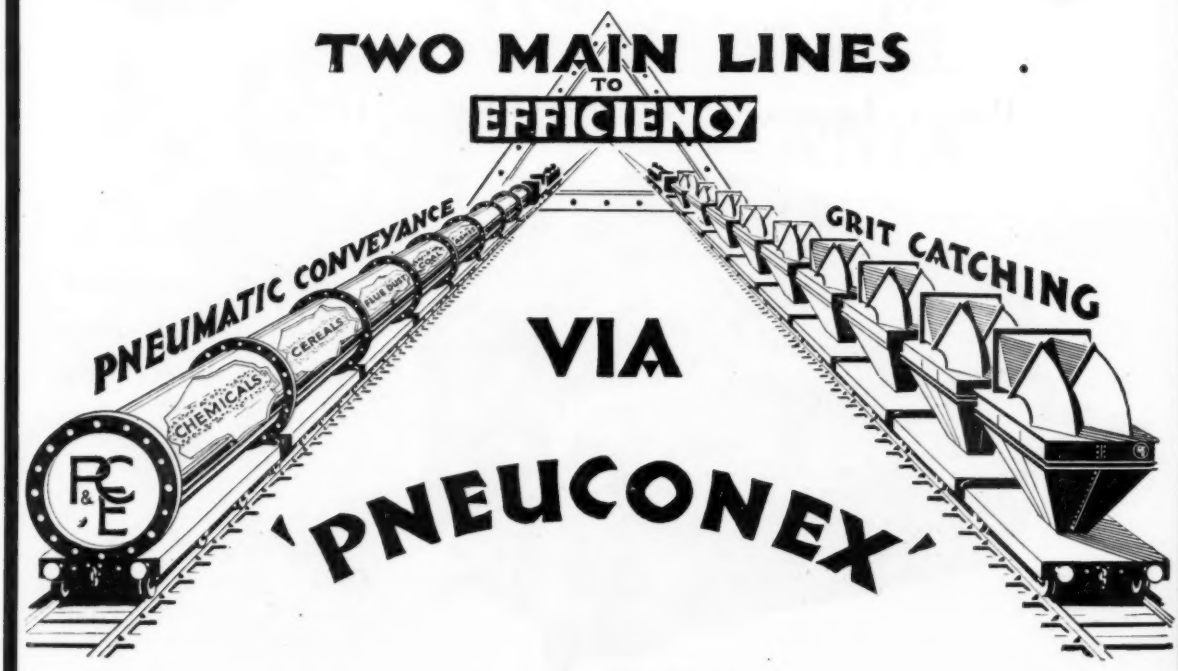

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from the

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We manufacture all kinds of Plant for Gas Works, and having a large "outside" staff are able to carry out expeditiously the RE-SHEETING AND ADDING OF LIFTS TO GASHOLDERS.

We should be pleased to have your enquiries for schemes you have in mind

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The "HURRY" WATER HEATER Co.

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Guaranteed British Metal and Labour.

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Circular, Corner, and Flat-Back Patterns (latter two very rigid when fitted).

Prevents Gas Connection getting broken.

Standard Burners, or Special Bunsen ditto.

Sprayed Copper or Aluminium Colour.

Gas and Air Adjusters—if desired.

Supplied with fitting, on our new method, to give Hot Water Supply to a Bath if desired.

Designs Patented and Registered.

Particulars Free.

THE VERY BEST CLOTHES WASH BOILER ON MARKET.

SPIRAL CENTRIFUGAL WASHERS

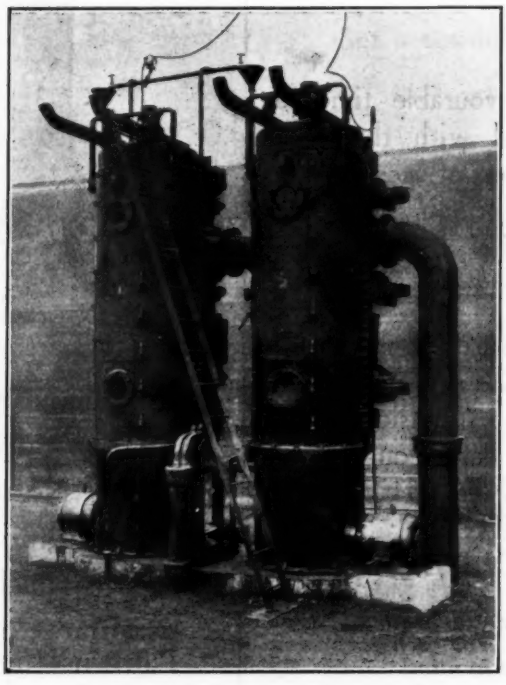
(BRITISH PATENTS 256351 and 256358)

FOR SMALL GASWORKS

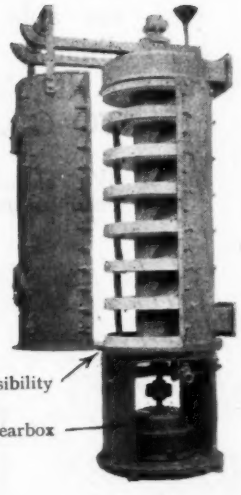
THESE MACHINES ARE IN USE BOTH FOR THE EXTRACTION OF AMMONIA AND NAPHTHALENE

MINIMUM COST

MAXIMUM EFFICIENCY



2'-6" CENTRIFUGAL WASHERS IN OPERATION FOR AMMONIA EXTRACTION AT WOLVERTON GASWORKS.



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Further, its great spreading and obliterating power makes it the most economical paint to use. You are thus ensuring a *double* saving when you specify Foochow — as well as giving your structures extra protection.

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Foochow Permanent Green Enamel Paints are completely stable against gas works fumes, having wearing properties equal to Red Oxide Paint. Let us send names of leading Gas Works where Foochow is used.

Why not write for testing samples?

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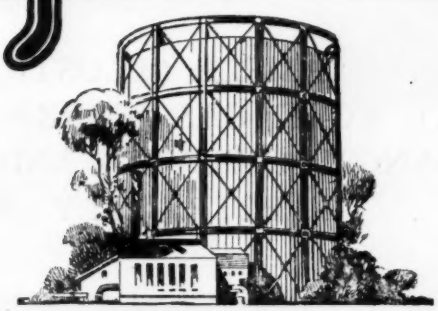
"More than Paint"



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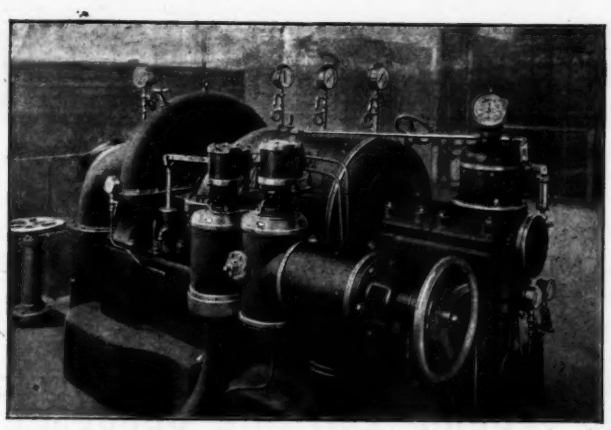

Single-stage, Star Type Gas Exhauster, combined with Multi-stage, High Speed Turbine, size suitable for ½ to 1 million c.ft. per hour, and pressure up to 120" W.G.

30% GAIN

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SINGLE STAGE GAS EXHAUSTERS FOR PRESSURES UP TO 120" W.G.

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Star Type Exhauster Sets

Representatives wanted for Great Britain and Dominions.

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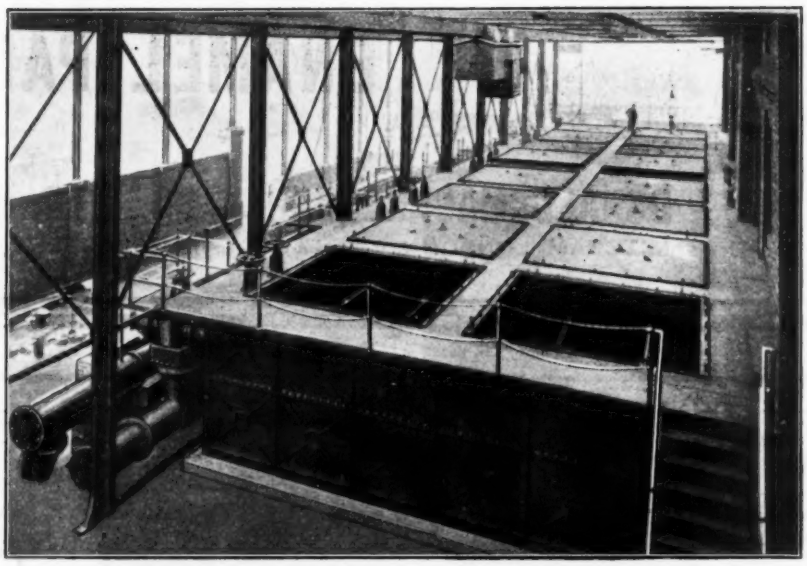
AN EXAMPLE (ILLUSTRATED BELOW) MAY BE SEEN AT YORK GAS WORKS WHERE THE WHOLE OF THE GANGWAY PLATES AND COVERS ARE IN MILD STEEL ELECTRICALLY WELDED THROUGHOUT.



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An installation of four Purifiers with Electrically Welded Mild Steel Tops and Bottoms for the Borough of Kendal is now under construction.

AN EXPERT STAFF ON PURIFIER DESIGNING IS AT YOUR SERVICE AND OUR REPRESENTATIVES WOULD BE PLEASED TO WAIT UPON YOU AT ANY TIME AND DISCUSS YOUR PROBLEMS.

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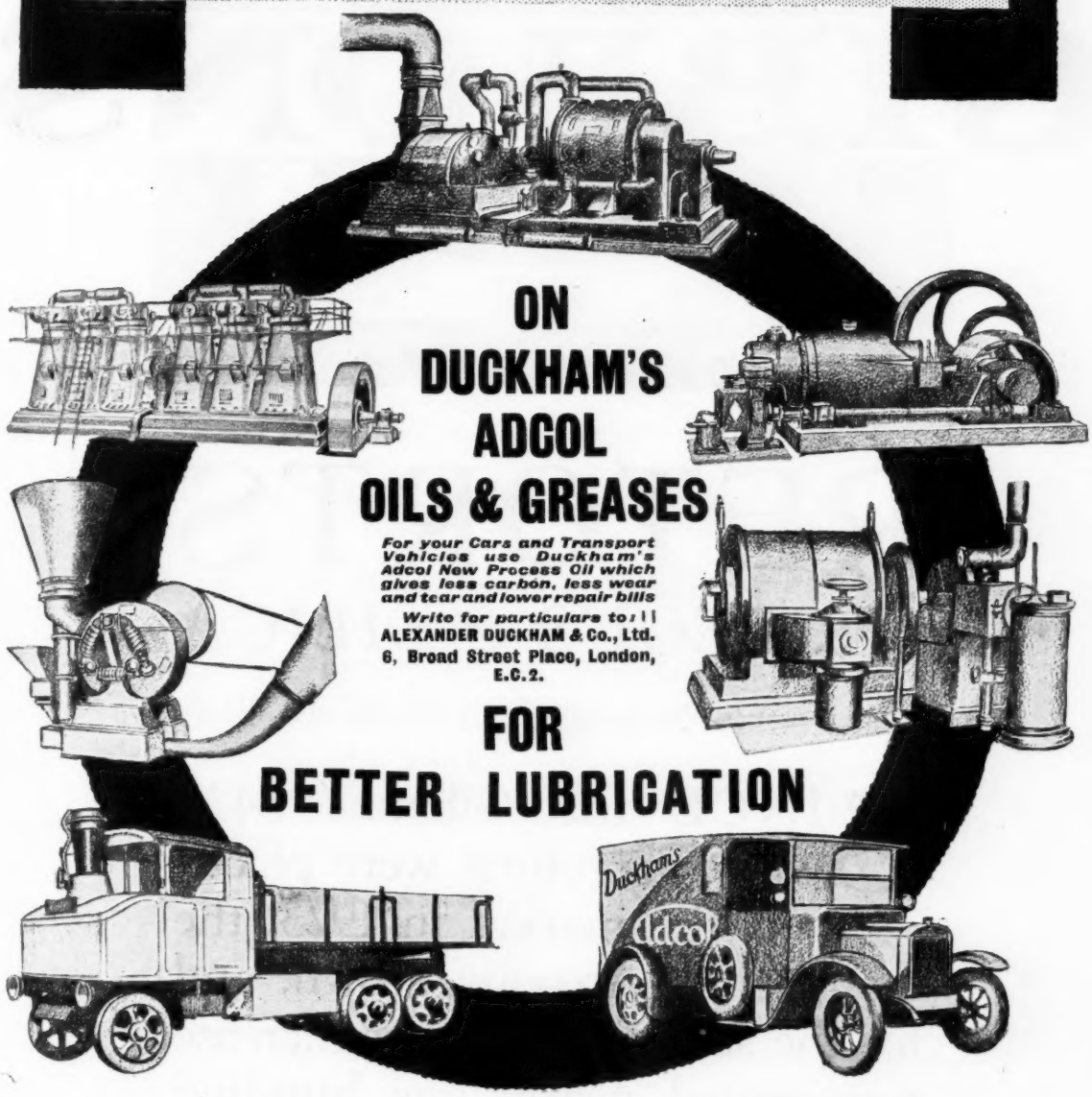

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For your Cars and Transport Vehicles use Duckham's Adcol New Process Oil which gives less carbon, less wear and tear and lower repair bills

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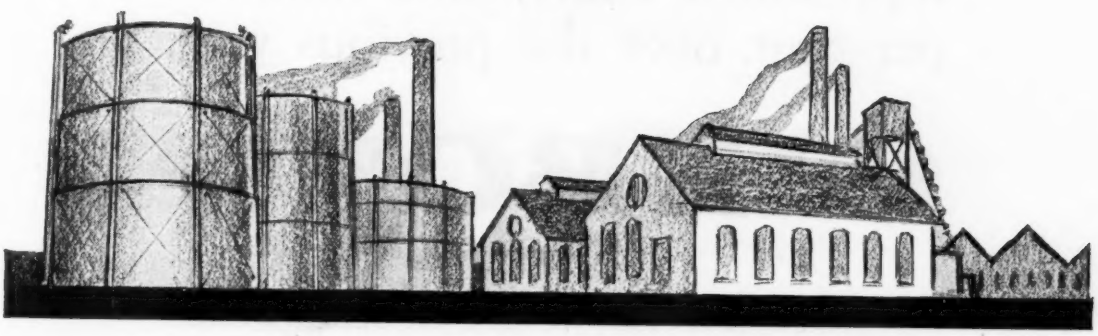

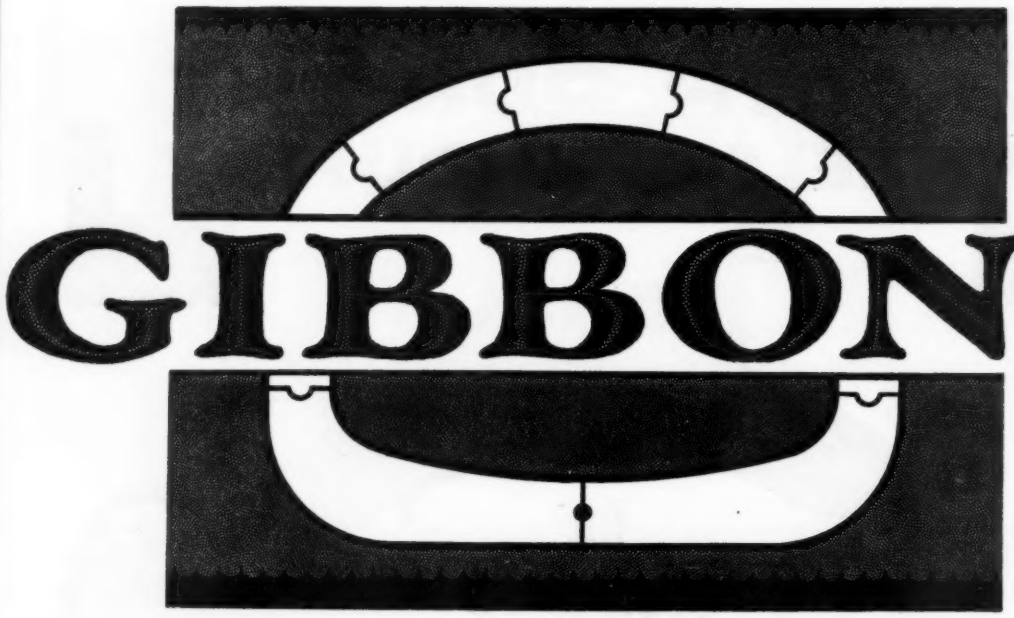

RETORTS

SILICEOUS & SILICA

SINCE the Gibbons 84% siliceous retorts were placed on the market in 1923, the demand has steadily grown, and for the season 1928/9 the increase represented nearly one hundred per cent. over the previous year.

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(DUDLEY LTD.)

Head Office: DIBDALE WORKS, DUDLEY, WORCS.

And at LONDON, BRISTOL, and MELBOURNE.

GASWORKS PLANT

COMPLETE HORIZONTAL & VERTICAL RETORT INSTALLATIONS, RETORT HOUSE BUILDINGS, RETORT BENCHES AND SETTINGS, REGENERATIVE FURNACES, CHARGING AND STOKING MACHINES (*Guest Gibbons Patent*), RETORT FITTINGS, FURNACE FITTINGS, GRILLE GRATE FURNACES, REFLUX SYSTEM, ELEVATORS, HOPPERS, AND CONVEYING MACHINERY, TELPHER TRACKS AND RUNS, GIBBONS & MASTERS PATENT TUBE FLUES, GIBBONS & MASTERS PATENT A B C TILES.

"KOGAG" COKE OVENS.

GIBBONS

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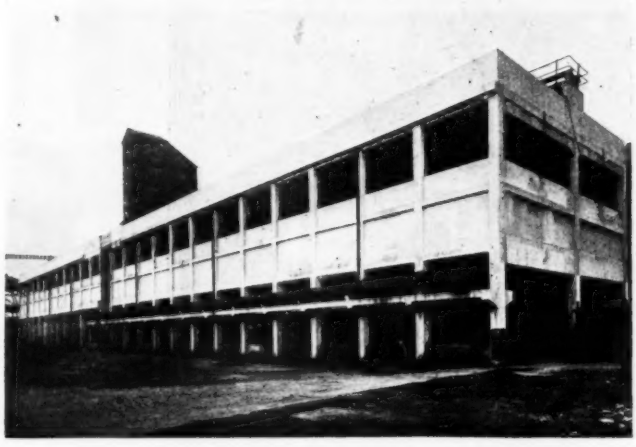

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ARE ALWAYS SPECIFIED WHEN

RELIABILITY and LOW RUNNING COSTS are desired

ELECTRIC, BELT OR ENGINE-DRIVEN IN ALL SIZES

FOR LARGE THROUGHPUT & MAXIMUM DRYNESS
THEY HAVE DEFIED COMPETITION FOR 60 YEARS

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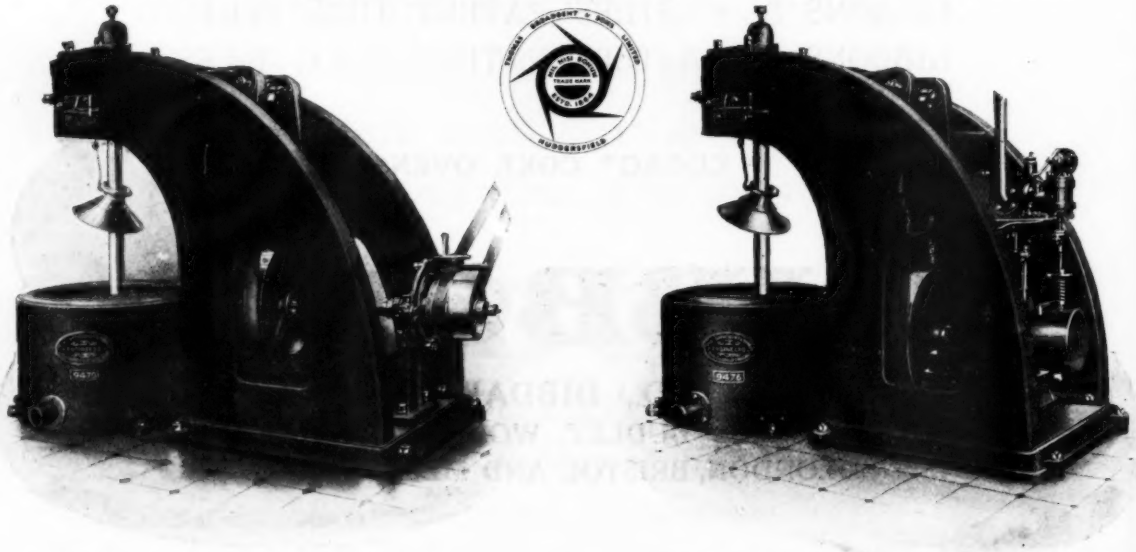
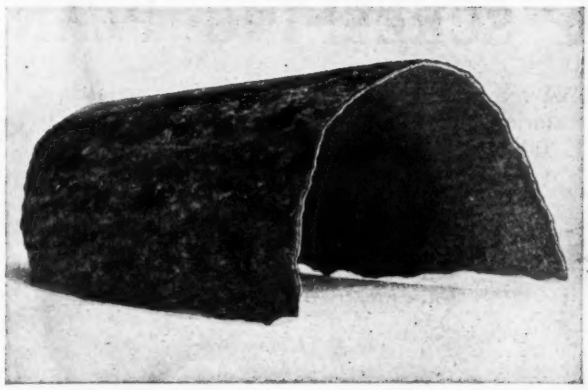


SWAN-NECK TYPE BELT-DRIVEN CENTRIFUGAL

SWAN-NECK TYPE ENGINE-DRIVEN CENTRIFUGAL

SIMPLY TAP with a mallet



Above is a photograph reproduced by courtesy of Messrs. J. Lyons & Co., Ltd., which shows how easily scale is removed from interior boiler surfaces that have been treated with "Apexior."

and Scale . . . . leaves like this.

WHEN the steam and water surfaces of boilers are painted with "Apexior Compound" little more than a mallet is needed for scaling.

Surfaces coated with "Apexior" are antagonistic to the building up of scale by the crystallisation process; the quantity of scale deposit is considerably lessened and entirely altered in character, being loose in texture and friable. Scale does not adhere to "Apexiorised" surfaces—it comes away easily over large areas when tapped with a wooden mallet or flat faced hammer, which obviates the use of chipping hammers with all consequent possibilities of damage to plates.

¶ You should also test "*Apexior No. 3*" on your Boiler Fronts, Uptakes, and Steel Chimneys. There is nothing like it.

Left is the package for Export.
Right is the package for Home Trade.

"Apexior" is applied like paint with a brush. One treatment on all surfaces in contact with steam or water gives effective protection for approximately one year at comparatively small cost. At least know how valuable "Apexior" is proving to be in most of the principal land and marine boiler installations.

¶ **Write for 10th Edition "Power and More Power" and "Nat: Physical Lab: Report on Heat Transmission." State whether land or marine booklet desired. Free. Dept. G.J.**

J. DAMPNEY & COMPANY LIMITED.

PROTECTIVE COATINGS APEXIOR REGISTERED FOR METAL SURFACES

BRITANNIC WORKS, NEWCASTLE-UPON-TYNE

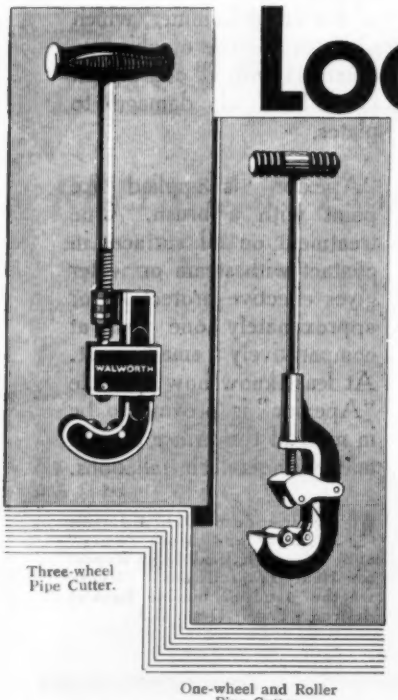
FRASER & CHALMERS ENGINEERING WORKS

F&C

COAL HANDLING & SCREENING PLANT

A recent installation at Plymouth for unloading, storing, and accurately screening coal. Capacity 200 tons per hour.
A typical Fraser & Chalmers-Robins Installation.

FRASER & CHALMERS ENGINEERING WORKS
PROPRIETORS THE GENERAL ELECTRIC CO. LTD
ERITH, KENT
LONDON OFFICE: MAGNET HOUSE, KINGSWAY, W.C.2
Associated with ROBINS CONVEYING BELT CO., of U.S.A.



Three-wheel Pipe Cutter.

One-wheel and Roller Pipe Cutter.

Look to your pipe cutters!

ARE you using the very best and the most efficient type obtainable, or are your cutters "doing the job pretty well"?

The New Walworth 3-Wheel Pipe Cutter has been tested exhaustively and its quality proved to be ahead of any other of its class. It is made with specially heat treated nickel alloy steel cutter wheels; the wheels have the sharpest edges possible—consistent with good practice; all wheels are the same thickness and interchangeable; hardened pins, with tapered ends, are fitted securely to the frame by driving the pin into a tapered frame hole; all our new 3-wheel cutters have a RED HANDLE. The latter is important for identifying the genuine tool.

The New Walworth One-Wheel Roller Cutter. Here is another first-rate Pipe Cutter, which does not disappoint in use. The wheel is specially heat treated alloy steel and cuts rapidly through the pipe, as the rollers which fit against the pipe and hold the cutter in position flatten out the burr left by the cutting edge.
This tool is also made with a RED HANDLE.

Full information about the various sizes of both tools will be given on request.

QUALITY AT WALWORTH'S

Specify WALWORTH

TUBES · FITTINGS · VALVES · TOOLS

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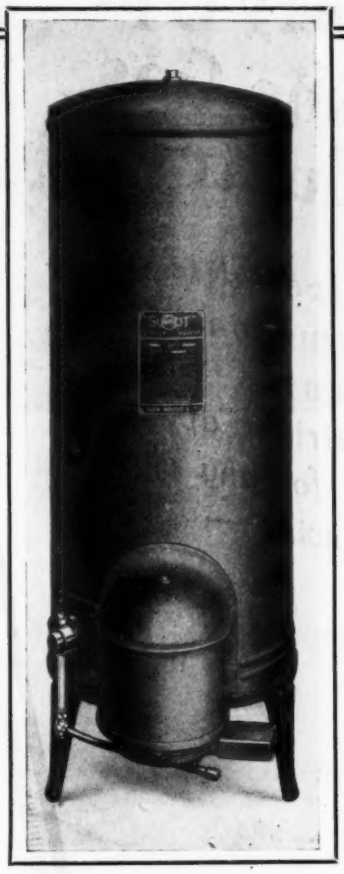
Constant HOT WATER
at a lower cost than ever before

THE "SUNHOT" Water Heater provides a constant supply of hot water for all domestic purposes at a surprisingly low cost. Its efficiency has been proved and the "SUNHOT" approved by architects for the Douglas Haig Memorial Homes at Bristol, and elsewhere. Independent tests have also been carried out by Gas Engineers all over the country, and in every case convincing proof has been obtained that the "SUNHOT" is unquestionably the best type of water heater that the gas industry has ever known.



SIX OUTSTANDING FEATURES OF THE "SUNHOT":

1. Hot water available at all times.
2. Hot water without attention.
3. Hot water at trifling cost.
   50 gallons of really hot water for 6d. a day, with gas at 3s. 2d. per 1000 cubic feet (500 B.Th.U. per cubic foot).
4. Automatic in operation, and foolproof.
5. Low cost of installation—no enlarged service pipes or meters.
6. Flue difficulties avoided.

WRIGHT'S
SUNHOT
REGULO-CONTROLLED

GAS WATER HEATERS

JOHN WRIGHT & CO., ESSEX WORKS, ASTON, BIRMINGHAM

(Radiation Ltd., Proprietors)

Buildings of every type for the Gas Industry.

We specialise in construction and welcome your inquiries at any time for any of the following:—

Horizontal Retorts
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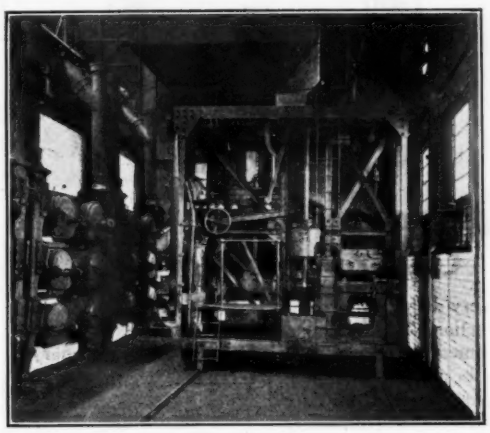
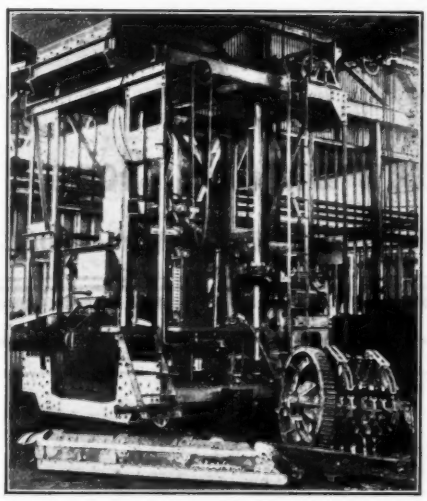
THE MULTIPLE STROKE MACHINE

THE IDEAL CHARGER FOR MEDIUM SIZED RETORT HOUSES

BURY ST. EDMUNDS →
(Similar machine also at Tamworth).





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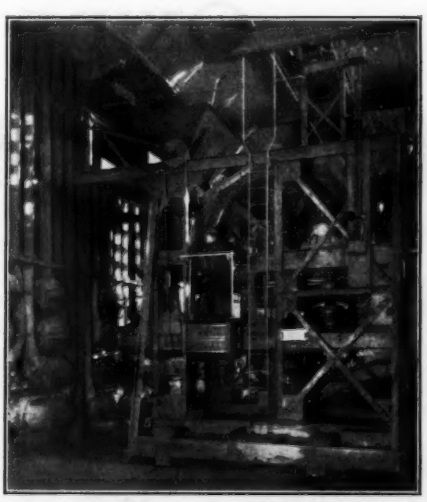
NOW IN COURSE OF CONSTRUCTION
AT OUR BATH WORKS

ONE OF OUR LATEST TYPE OF
STANDARD SIMULTANEOUS
RETORT CHARGERS
AT
WESTON-SUPER-MARE. →



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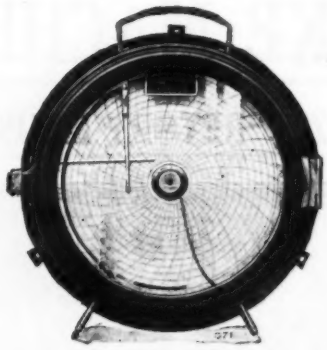

Drayton Gas Works Control Instruments

Every detail in the construction of Drayton instruments receives the most careful attention, having in mind the duty which they will ultimately be called upon to perform.

The natural result is the production of instruments which have every refinement for convenience, in addition to the capacity for long and satisfactory service.

The illustration shows the Drayton Portable Pressure Recorder which is available for any standard range of pressure, vacuum or draught.

The DRAYTON REGULATOR and INSTRUMENT CO LTD
WEST DRAYTON MIDDLESEX

92A

THE MOORE GAS PLANT

□ □ □

HIGHEST Thermal Efficiency

LOWEST Capital & Working Costs

Produces Coal Gas, Water Gas, or Mixed Gas in any desired proportions

NO CLINKERING

□ □ □

Full Particulars may be obtained from the : : Licensees and Manufacturers : :

Andrew Barclay, Sons & Co.
LTD.,
CALEDONIA WORKS, KILMARNOCK.

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OXIDE DISINTEGRATOR.

Construction based on many years' experience.
Most up-to-date method of revivifying spent Oxide.
Handles wet or dry Oxide, no matter how hard the lumps.
Throws material 50 feet in any direction.
Power consumption is very low.
Considerable saving as against hand labour.
Manufactured in three sizes.

LET US HAVE YOUR ENQUIRIES.

ATMER & BOOTH, Ltd.,
67, SOUTHWARK STREET,
LONDON, :: S.E. 1.

Telegrams: "Atmeroh, Boroh." Telephone: HOP 6481.

LOOK!!!

"Coleman" Oxide Disintegrating Machine

SENT TO ANY GAS UNDERTAKING IN GREAT BRITAIN ON TRIAL AGAINST COMPETITIVE MACHINES

The only Machine which simultaneously revivifies, aerates, and disintegrates Oxide *in one operation.*

Large pieces do not have to be broken to be fed into our Machine. It will take chunks up to 12" in. diameter, any length.

Will also disintegrate sulphate of ammonia, will stack coal and has been found to be the speediest method of handling a stack of coal that has fired.

British Built Throughout

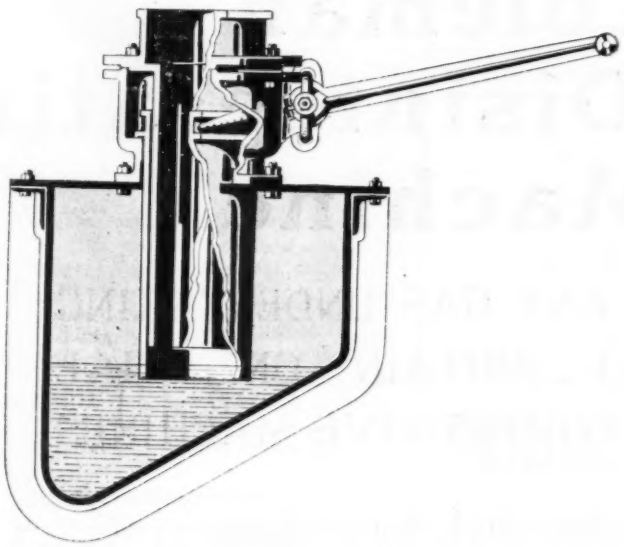
COLEMAN

Oxide Disintegrators : Pneumatic Tools
Pneumatic Digging Spades for Purifying Boxes

COLEMAN FOUNDRY EQUIPMENT CO., Ltd.

1, Lancaster Place, Strand, London, W.C. 2

An essential to modern Gas Works practice



CORT'S PATENT ANTI-DIP VALVE

Has proved itself after long and constant service to be of outstanding efficiency. To obtain the maximum results from your existing or proposed settings its installation is an essential of modern practice.

Definite advantages obtainable with this apparatus are:—

1. **Increased make per ton.**
2. **Each retort under separate control (pipe plugging dispensed with).**
3. **Trouble with stopped pipes eliminated.**
4. **Permits working at level gauge, thus avoiding the drawing in of inerts.**
5. **Scurfing reduced by 50%.**
6. **Overcomes the trouble of uneven seals where double ascension pipes are used.**
7. **Dispenses with the need for taking seals after lighting up beds.**
8. **Ability to flush out hydraulic main completely and thus remove the thick tar.**
9. **Will replace ordinary dip pipes without alteration to main cover.**

These Valves are now in use in approximately 200 Gasworks (a few of which are appended), and we continue to receive most satisfactory reports as to their working, fully confirming our claims for them.

Aldershot	Clevedon	His Majesty's Fuel Research Station	Peterborough
Bristol	Colchester	Haslemere	Rochester
Beckton	Doncaster	King's Lynn	Spenborough
Brierly Hill	Fulham	Leeds	Snodland
Cambridge	Glastonbury	Newark	Scarborough
Chelmsford	Gosport	Oxford	Weston-super-Mare
	Hertford		York, etc., etc.

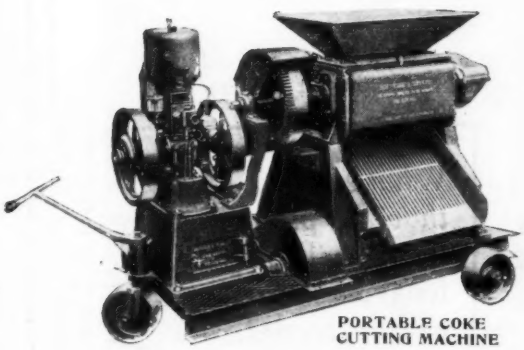
ROBERT CORT & SON LIMITED

Reading Bridge Ironworks—READING

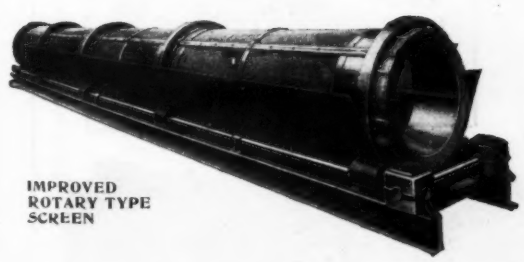
Supremacy

Wandsworth, Wimbledon, & Epsom District Gas Co.—Mitcham.

CORT'S COKE CUTTING & GRADING PLANT



PORTABLE COKE CUTTING MACHINE

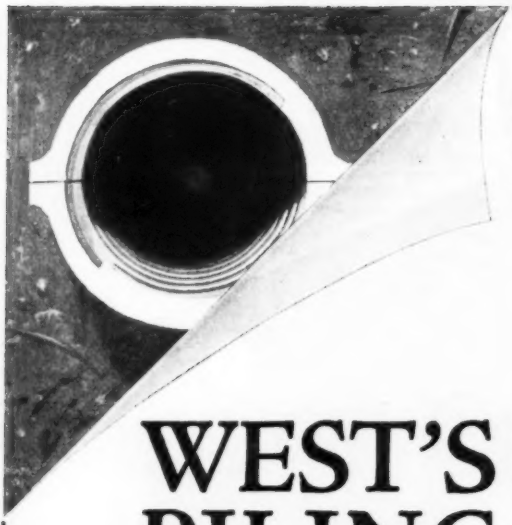


IMPROVED ROTARY TYPE SCREEN

"TO BE RATHER THAN TO SEEM TO BE."

That our business—or rather our Service—is 90% specialisation in Coke Grading Plant and the fact that the vitals—if not the complete job—in the most modern plants now being installed are "Cort's," is sufficient reason that you should—whether your requirements be small or large—take advantage of a lengthy experience of the subject which we believe to be without equal.

ROBERT CORT & SON, LTD.
Reading Bridge Iron Works
READING



The photograph shows a view looking down a Rotinoff shell-pile, demonstrating how easily it is inspected after driving and before pouring the concrete.

WEST'S ROTINOFF PILING

is pre-cast concrete shell-piling, filled with concrete after driving. Every Rotinoff shell-pile can be inspected *after* it is driven, and its soundness verified. Over 40,000 feet of Rotinoff shell-piles has already been driven, and every engineer who has seen them driven has been impressed with the soundness of our claims for Rotinoff piling.

OTHER POINTS OF ROTINOFF PILING

The bearing capacity of the pile is undisturbed, for the shell is not withdrawn but—with the shoe—remains exactly as driven, and the frictional grip is retained just as in the final "set." The "green" concrete core of the driven pile is well protected while driving adjacent piles, by the rigid concrete shell. The internal inspection of the driven pile-shell from top to bottom gives a check upon the actual pile resulting, so that it can safely be stressed to the fullest extent. Pile driver not required for concreting, which is done by a separate gang from ground level.

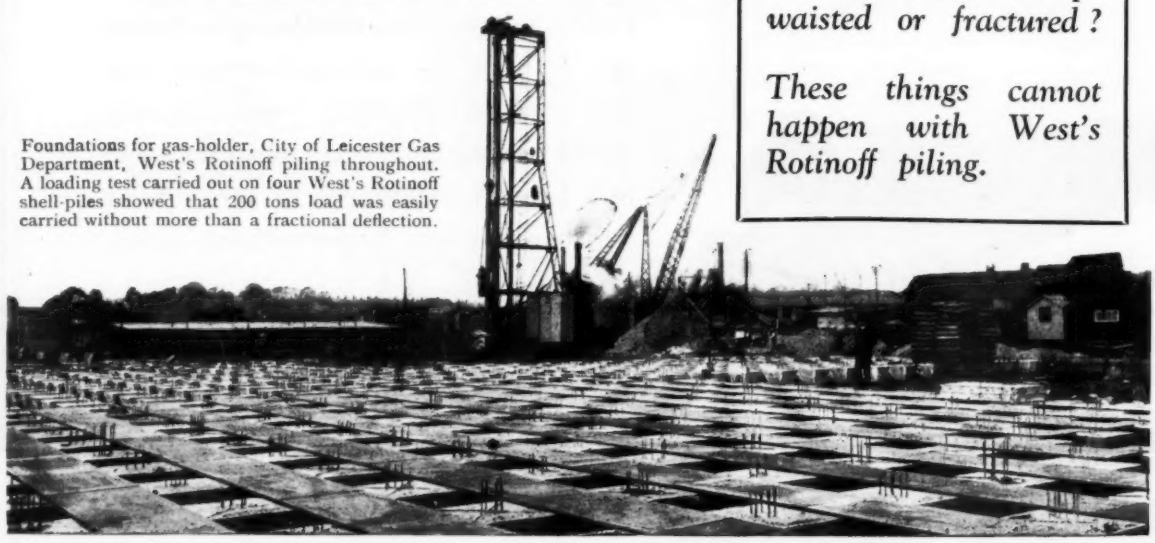
Owing to the short unit length of the pile-shell, there is no wastage of time or material in cutting overlong piles or building up short piles. No heavy handling or pitching is involved: concrete shells are small units cast on site. The cost of Rotinoff Piling is cheaper than pre-cast piling.

WEST'S ROTINOFF PILING AND CONSTRUCTION COMPANY, LTD.
REGENT HOUSE, KINGSWAY, W.C. 2

Designs for Foundations, and further information, with illustrated brochure, free on request.

What evidence have you that the piling you are using will not be too long, too short, damaged or deflected, wasp-waisted or fractured?

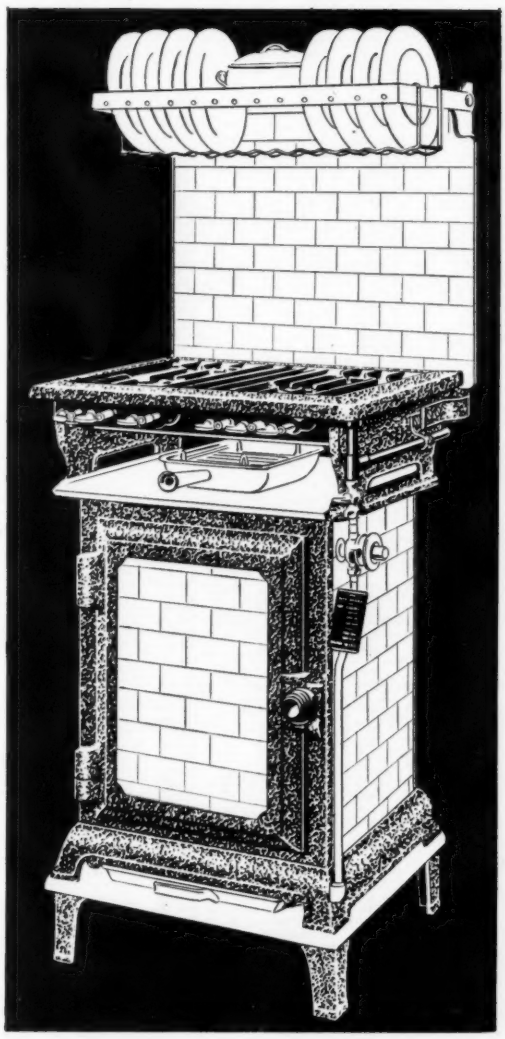
These things cannot happen with West's Rotinoff piling.



Foundations for gas-holder, City of Leicester Gas Department, West's Rotinoff piling throughout. A loading test carried out on four West's Rotinoff shell-piles showed that 200 tons load was easily carried without more than a fractional deflection.

PORCELIRON

★ *As long ago as the International Gas Exhibition (Crystal Palace) 1901 we exhibited one of our Cookers with Porcelain Enamelled Cast Iron Linings, which, even at that time, had already been in use for several years.*



OUR experience of enamelling is unique in the Gas Industry, and for these reasons :—

The enamelling of Hollow-ware was carried on at the Cannon Iron Foundries long before most modern firms were in existence.

For many years Cannon Hard Grey Enamel has been, and is still regarded as one of the finest vitreous surfaces in the Chemical Industry, being used extensively for the production of fine chemicals when the slightest impurity would be disastrous.

All this experience, plus more than a hundred years' reputation for foundry work, goes into the making of Porceliron-enamelled cookers.

As far as appearance is concerned, it is generally agreed that the finish is considerably superior to the ordinary "Mottle."

As for wearing qualities—time will show.

CANNON

Head Office and Works : Deepfields, Nr. Bilston, Staffs. London Office and Showrooms : Bath House, 57|60, Holborn Viaduct, E.C. 1.

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WATER-GAS

	Cu. Ft. Daily
Aarhus	800,000
Abertillery	500,000
Abertillery	100,000
Admiralty:	
British	800,000
British	800,000
British	800,000
British	800,000
British	800,000
French	800,000
French	800,000
Agram	200,000
Airdrie	430,000
Aldershot	1,400,000
Aldershot	1,000,000
Aldershot	1,316,000
Algiers	1,760,000
Alkmaar	400,000
Allenstein	200,000
Alost	700,000
Amersfoort	300,000
Amsterdam	1,000,000
Amsterdam	1,000,000
Amsterdam	2,700,000
Amsterdam	1,350,000
Antwerp	1,500,000
Antwerp	1,000,000
Antwerp	1,500,000
Antwerp	1,900,000
Arundel	215,000
Ascot	423,000
Ashford	250,000
Augsburg	425,000
Aylesbury	150,000
Aylesbury	470,000
Banbury	200,000
Banff	125,000
Barmen	500,000
Barnsley	300,000
Barrow	300,000
Barrow	500,000
Barry	500,000
Barry	720,000
Bath	1,000,000
Bath	1,000,000
Bath	1,300,000
Bath	1,200,000
Bedford	1,000,000
Belfast	1,700,000
Belfast	4,500,000
Belfast	1,250,000
Belfast	1,250,000
Belfast	2,250,000
Benrath	125,000
Berkhampstead	259,000
Berlin:	
Charlottenb'g	2,500,000
Danziger Str.	1,600,000
Neukoelin	650,000
Neukoelin	700,000
Schmargendorf	760,000
Tegel	3,500,000
Tegel	6,350,000
Tegel	245,000
Berne, Switz.	725,000
Bexhill	400,000
Bideford	258,000
Bilston	375,000
Bilston	125,000
Birmingham:	
Adderley St.	675,000
Adderley St.	850,000
Nechells	3,000,000
Nechells	3,000,000
Nechells	3,000,000
Nechells	7,650,000
Swan Village	1,500,000
Windsor St.	3,000,000
Windsor St.	3,000,000
Windsor St.	6,100,000
Bishop's Stortford	200,000
Bishop's Stortford	300,000
Bishop's Stortford	200,000
Bishop's Stortford	300,000
Blackburn	1,190,000
Blantyre	150,000
Blois	125,000
Blois	125,000
Bochum	530,000
Bognor	100,000
Bognor	423,000
Bognor	500,000
Bo ness	125,000
Boulogne	340,000
Bournemouth	1,000,000
Bournemouth	500,000
Bournemouth	1,500,000
Bournemouth	1,000,000
Bournemouth	500,000
Bournemouth	1,530,000
Bournemouth	2,000,000
Bournemouth	500,000
Bournemouth	2,750,000
Bradford	1,260,000
Bremen	550,000
Bremen	950,000
Bremen	850,000
Brentwood	250,000
Brescia	588,000
Brescia	588,000
Brest	550,000
Bridgwater	200,000
Bridlington	150,000
Bridlington	200,000
Bridlington	550,000
Brieg	100,000
Brierley Hill	250,000
Brierley Hill	425,000
Brighton	1,750,000
Brighton	1,850,000
Brighton	750,000
Brighton	2,750,000
Brighton	3,000,000
Bristol	2,000,000
Bristol	2,500,000
Bristol	825,000
Bristol	825,000
Bromley	1,500,000
Bruges	200,000
Bruges	600,000

Brussels:	Cu. Ft. Daily
Anderlecht	350,000
Anderlecht	350,000
Forest	1,000,000
Forest	1,000,000
Forest	1,000,000
Forest	1,500,000
Forest	88,000
Koekelberg	1,000,000
St. Gilles	1,000,000
St. Josse	1,000,000
St. Josse	600,000
St. Josse	775,000
Ville	750,000
Ville	750,000
Ville	1,500,000
Ville	350,000
Bucarest	1,100,000
Buckie	164,000
Budapest	50,000
Budapest	1,750,000
Budapest	200,000
Budapest	250,000
Burnley	1,350,000
Caen	250,000
Cambridge	500,000
Cambridge	1,000,000
Cambridge	1,700,000
Cardiff	2,000,000
Cardiff	3,050,000
Cardiff	1,950,000
Cardiff	800,000
Carlisle	600,000
Carlsruhe	500,000
Carnarvon	248,000
Charleroi	1,250,000
Châteauroux	125,000
Châteauroux	125,000
Châtelet	500,000
Chester	300,000
Chesterfield	430,000
Chesterfield	90,000
Chesterton	197,000
Chichester	250,000
Chorley	300,000
Cie. des Compteurs	1,150,000
Cie. Lorraine de Ch.	210,000
Cie. Minesde Roche	585,000
Coatbridge	400,000
Commercial, L'n	850,000
Commercial	850,000
Commercial	1,250,000
Commercial	2,000,000
Commercial	800,000
Commercial	2,100,000
Copenhagen	700,000
Copenhagen	2,300,000
Copenhagen	1,750,000
Copenhagen	1,200,000
Courtrai	250,000
Coventry	600,000
Coventry	600,000
Coventry	800,000
Coventry	1,250,000
Coventry	350,000
Cowdenbeath	420,000
Cracow	200,000
Cracow	200,000
Cranleigh	188,000
Crefeld	500,000
Crewe	700,000
Crewe	800,000
Crosfield & Sons	1,560,000
Crosfield & Sons	1,750,000
Crowborough	150,000
Croydon	1,250,000
Croydon	625,000
Croydon	625,000
Croydon	550,000
Croydon	650,000
Croydon	1,125,000
Croydon	150,000
Croydon	3,000,000
Croydon	6,000,000
Deal	250,000
Deal	250,000
Debreczin	100,000
Derby	1,500,000
Derby	2,000,000
Deventer	150,000
Deventer	200,000
Devonport	1,600,000
Devonport	1,100,000
Doncaster	1,350,000
Dorking	150,000
Dorking	300,000
Dorking	130,000
Dover	500,000
Dublin	2,000,000
Dublin	2,000,000
Dublin	650,000
Dudley	600,000
Dundee	1,500,000
Dundee	1,650,000
Dunedin, N.Z.	150,000
Dunedin	275,000
Durham	200,000
Dusseldorf	1,000,000
Eastbourne	1,250,000
Eastbourne	1,550,000
Edinburgh	2,000,000
Eindhoven	1,500,000
Electro-Chimie	650,000
Enschede	282,000
Epping	500,000
Epsom	225,000
Epsom	300,000
Essen	1,400,000
Essen-Borbeck	1,400,000
Exeter	1,100,000
Exeter	1,200,000
Exmouth	376,000
Falmouth	150,000
Falmouth	200,000
Faversham	200,000
Flensburg	300,000
Flensburg	125,000
Fond. del Pignone	164,000
Forst	300,000
Frankenthal	175,000

	Cu. Ft. Daily
Fuel Research Wks.	500,000
Fuel Research Wks.	500,000
Furnes	500,000
Gablonz	140,000
Gas L. & C. Co.:	
Beckton	10,000,000
Beckton	7,000,000
Beckton	3,500,000
Beckton	7,000,000
Beckton	7,000,000
Beckton	5,250,000
Beckton	4,500,000
Beckton	3,000,000
Beckton	1,500,000
Bow Common	1,000,000
Bow Common	1,150,000
Bow Common	150,000
Brentford	1,200,000
Brentford	850,000
Brentford	350,000
Brentford	750,000
Bromley	3,750,000
Bromley	2,250,000
Bromley	1,000,000
Bromley	1,000,000
Bromley	1,000,000
Bromley	1,450,000
Bromley	1,350,000
Fulham	2,500,000
Fulham	1,700,000
Grays	250,000
Grays	400,000
Grays	725,000
Ilford	650,000
Ilford	750,000
Kensal Green	2,250,000
Kensal Green	2,250,000
Kensal Green	2,250,000
Nine Elms	2,750,000
Nine Elms	750,000
Nine Elms	1,870,000
Nine Elms	2,850,000
Shoreditch	900,000
Shoreditch	2,700,000
Shoreditch	2,725,000
Southall	2,000,000
Southall	3,000,000
Staines	600,000
Stratford	1,700,000
Stratford	850,000
Stratford	2,350,000
Stratford	2,350,000
Gelsenkirchen	175,000
Gelsenkirchen	350,000
Geneva	500,000
Geneva	700,000
Geneva	1,270,000
Gennevilliers	10,600,000
Gennevilliers	2,900,000
Girvan	235,000
Glasgow	3,000,000
Glasgow	2,500,000
Glasgow	2,250,000
Glossop	340,000
Gloucester	800,000
Gloucester	1,000,000
Gosport	200,000
Gosport	225,000
Göteborg	300,000
Göteborg	600,000
Graudenz	200,000
Groningen, Holland	500,000
Guest Keen & Piggotts, Ltd.	
	1,936,000
Guildford	350,000
Guildford	200,000
Guildford	350,000
Guildford	1,100,000
Guildford	150,000
Haarlem	850,000
Hamburg	1,750,000
Hampton Court	500,000
Hampton Court	600,000
Hampton Court	1,100,000
Hanley	800,000
Hanley	800,000
Hartlepool	750,000
Hartlepool	765,000
Hastings	1,250,000
Haywards Heath	470,000
Hebden Bridge	200,000
Heidelberg	200,000
Hereford	525,000
Hertford	197,000
Hertford	244,000
Hessle	150,000
Heywood	500,000
High Wycombe	752,000
Hilversum	850,000
Hinckley	250,000
Holyhead	197,000
Hong Kong	450,000
Hong Kong	450,000
Hornsey	1,000,000
Hornsey	1,000,000
Hornsey	750,000
Hornsey	750,000
Horsham	235,000
Hull	1,500,000
Hull	1,000,000
Hull	1,600,000
Innsbruck	200,000
Ipswich	750,000
Ipswich	1,250,000
Ipswich	600,000
Jersey	564,000
Jersey	564,000
Kampen	350,000
Karlsbad	350,000
Kendal	229,000
Kidsgrove	235,000
Kiel	1,000,000
Kiel	880,000
Kilmarnock	500,000
Kilmarnock	585,000
King's Lynn	197,000
King's Lynn	400,000
Kingston-on-Th.	3,400,000
Kirkintilloch	360,000
Kirkintilloch	827,000

	Cu. Ft. Daily
Kolozvar	100,000
Lancaster	500,000
Langley Mill	500,000
Largs	235,000
Lausanne	250,000
Lausanne	385,000
Lausanne	970,000
Le Mans	420,000
Lea Bridge	350,000
Lea Bridge	350,000
Lea Bridge	400,000
Lea Bridge	1,000,000
Lea Bridge	1,500,000
Lea Bridge	1,530,000
Leamington	600,000
Leamington	525,000
Leatherhead	705,000
Leeds	1,500,000
Leeuwarden	400,000
Leiden	500,000
Leiden	575,000
Leigh	350,000
Lemberg	260,000
Lemberg	500,000
Letchworth	362,000
Letchworth	423,000
Liege	1,000,000
Liege	750,000
Lille	860,000
Lincoln	500,000
Lincoln	893,000
Liverpool	3,500,000
Liverpool	4,500,000
Liverpool	750,000
Liverpool	1,750,000
Liverpool	1,250,000
Liverpool	3,000,000
Liverpool	1,500,000
Liverpool	1,250,000
Liverpool	2,350,000
Liverpool	3,000,000
Long Eaton	430,000
Long Eaton	170,000
Longton	600,000
Louvain	800,000
Lubeck	400,000
Luton	400,000
Maastricht	200,000
Macclesfield	800,000
Magdeburg	1,400,000
Maidenhead	225,000
Maidenhead	225,000
Maidenhead	175,000
Maidenhead	175,000
Maidenhead	200,000
Maidenhead	200,000
Maidstone	500,000
Maidstone	500,000
Malines	500,000
Malines	575,000
Malmö	350,000
Malta	400,000
Manchester	3,500,000
Manchester	3,500,000
Manchester	1,500,000
Mansfield	330,000
Mansfield	493,000
Margate	960,000
Marlborough	100,000
Mayence	700,000
Melbourne	5,000,000
Merthyr Tydfil	300,000
Merthyr Tydfil	200,000
Middlesbrough	1,250,000
Middlesbrough	750,000
Middlesbrough	900,000
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Monaco	618,000
Monaco	618,000
Monaco	400,000
Complete Gasification	
Mons	500,000
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Moscow	1,000,000
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Nelson	400,000
Nelson	350,000
Neuss	140,000
Newbury	250,000
Newcastle	2,500,000
Newcastle, N.S.W.	500,000
Newhaven	235,000
Newport Pagnell	188,000
Nice	900,000
Nictheroy	250,000
North Middlesex	200,000
North Middlesex	200,000
North Middlesex	1,000,000
North Middlesex	1,600,000
North Middlesex	800,000
Complete Gasification.	
North Middlesex	900,000
2nd Complete Gasification.	
North Sydney	500,000
North Sydney	500,000
Norwich	1,000,000
Norwich	300,000
Norwich	500,000
Norwich	1,500,000
Nottingham	1,000,000
Nottingham	1,000,000
Nuneaton	125,000
Oberhausen	175,000
Oldbury	500,000
Oldenburg	200,000
Ormskirk	170,000
Ostend	100,000
Ostend	200,000
,, Zandvoorde	700,000
Oxford	4,500,000
Palermo	968,000

	Cu. Ft. Daily
Palermo	850,000
Paris:	
Clichy	4,000,000
Ivry	2,350,000
Landy	6,000,000
Landy	6,000,000
Landy	5,295,000
La Villette	4,000,000
La Villette	2,000,000
St. Mandé	785,000
Paris-Plage	125,000
Pau	550,000
Pavie	194,000
Pavie	212,000
Pembroke	240,000
Perigueux	350,000
Perth, W.A.	125,000
Perth, W.A.	1,000,000
Petone, N.Z.	200,000
Piggott & Co.	1,500,000
Plymouth	2,000,000
Poitiers	350,000
Pontypool	120,000
Port Elizabeth	400,000
Portsmouth	1,000,000
Portsmouth	2,000,000
Portsmouth	800,000
Portsmouth	2,000,000
Posen	450,000
Posen	700,000
Prague	140,000
Preston	1,400,000
Ramsgate	430,000
Reading	1,000,000
Reading	1,000,000
Reading	600,000
Redditch	500,000
Redhill	275,000
Redhill	300,000
Redhill	1,100,000
Reichenberg	200,000
Reichenberg	200,000
Reval	350,000
Rhymney	175,000
Rhymney	250,000
Riddings	258,000
Ripley	120,000
Rochester	2,200,000
Rochester	2,800,000
Romford	300,000
Romford	350,000
Romford	1,200,000
Rotterdam	850,000
Rotterdam	1,500,000
Rotterdam	750,000
Rotterdam	750,000
Rotterdam	600,000
Rotterdam	2,000,000
Rotterdam	500,000
Royston (Yorks.)	250,000
Rugby	1,000,000
Rugby	450,000
Rushden	425,000
Rushden	517,000
Rydal	500,000
Saffron Walden	235,000
St. Albans	700,000
St. Albans	580,000
St. Andrews	210,000
St. Andrews	403,000
St. Gallen	225,000
St. Gallen	225,000
Ste. Croix Paroisse	1,320,000
Sté. Kuhlmann	1,270,000
Sté. Kuhlmann	3,200,000
Sté. Kuhlmann	2,150,000
Sté. Tubes Meuse	545,000
San Paulo	700,000
Scarborough	800,000
Scarborough	200,000
Scarborough	350,000
Scarborough	1,300,000
Scarborough	1,350,000
Seaford	200,000
Shanghai	225,000
Shanghai	225,000
Shanghai	1,600,000
Shanklin	259,000
Shanklin	400,000
Shanklin	200,000
Sheerness	180,000
Sheerness	200,000
Sheerness	220,000
Sheffield	1,530,000
Sheffield	3,000,000
,, Steel Prods.	3,000,000
Shirebrook	600,000
Shrewsbury	300,000
Shrewsbury	170,000
Sidmouth	225,000
Singapore	600,000
Sittingbourne	259,000
Southampton	800,000
Southampton	500,000
Southampton	600,000
Southampton	100,000
Southampton	1,000,000
Southampton	1,450,000
Southend	1,250,000
Southend	900,000
Southend	900,000
Southend	600,000
Southgate	400,000
Southgate	500,000
Southgate	800,000
Southgate	500,000
Southport	750,000
Southport	900,000
Southport	900,000
Southport	450,000
South Shields	650,000
South Shields	1,250,000
Stafford	500,000
Stettin	880,000
Stirling	400,000
Stirling	970,000
Stockholm	1,500,000
Stockholm	1,750,000
Stockport	600,000
Stockport	600,000

	Cu. Ft. Daily
Stockport	400,000
Stockport	400,000
Stockton	500,000
Stockton	250,000
Stourbridge	500,000
Stourbridge	500 000
Sunderland	2,250,000
Sunderland	300,000
Sutton	1,269,000
Sutton	1,625,000
Swanage	300,000
Swansea	750,000
Swansea	1,000,000
Swansea	450,000
Swansea	1,250,000
Swansea	2,000,000
Swindon	300,000
Swindon	450,000
Swindon	400,000
Sydney	1,000,000
Sydney	1,000,000
Sydney	1,000,000
Sydney	1,000 000
Sydney	8,250,000
Taunton	225,000
Taunton	350,000
Tawe Valley	275,000
Teignmouth	200,000
The Hague	1,000,000
The Hague	500,000
The Hague	1,750,000
The Hague	1,500,000
The Hague	775,000
The Hague	1,500,000
The Hague	2,930,000
Tilburg	400,000
Tirlemont	120,000
Tokyo	2,000,000
Torquay	350,000
Torquay	350,000
Torquay	320,000
Tottenham	750,000
Tottenham	750,000
Tottenham	350,000
Tottenham	1,000,000
Tottenham	1,000,000
Tottenham	1,250,000
Tottenham	2,500,000
Tottenham	1,000,000
Tottenham	500,000
Tottenham	1,000,000
Toulouse	1,800,000
Toulouse Natl. Wks.	2,400,000
Toulouse Natl. Wks.	6,200,000
Tournai	700,000
Tours	550,000
Trowbridge	250,000
Trowbridge	150,000
Tunbridge Wells	1,000,000
Tunbridge Wells	1,000,000
Tunis	175,000
Tynemouth	1,100,000
Tynemouth	1,100,000
Ulm	400,000
Union Chim.-Belge	1,977,000
Utrecht	1,000,000
Utrecht	1,000,000
Uxbridge	752,000
Uxbridge	1,000,000
Vancouver	3,800,000
Verviers	1,000,000
Vevey, Switz.	650,000
Victoria, B.C.	500,000
Vienna	3,500,000
Vienna	2,500,000
Walsall	750,000
Walsall	375,000
Waltham	400,000
Waltham	140,000
Walton-on-Thames	970,000
Wandsbek	125,000
Wandsworth	1,800,000
Wandsworth	4,230,000
Wanganui, N.Z.	376,000
Ware	150,000
Ware	282,000
Warwick	125,000
Wasmuel	500,000
Watford	300,000
Watford	350,000
Watford	400,000
Watford	1,250,000
Wath	430,000
Weimar	100,000
Wellingborough	525,000
Wellingborough	525,000
Wellingborough	550,000
Wellington, N.Z.	350,000
Wellington	300,000
West Bromwich	550,000
Westgate	250,000
Weston-Mare	350,000
Weston-Mare	350,000
Weston-Mare	150,000
Weston-Mare	150,000
Weston-Mare	500,000
Wexford	100,000
Weymouth	400,000
Weymouth	100,000
Weymouth	658,000
Whitstable	423,000
Widnes	500,000
Wiesbaden	850,000
Wigston	250,000
Winchester	225,000
Winchester	125,000
Winchester	410,000
Winchester	325,000
Woking	400,000
Wolverhampton	1,500,000
Wolverhampton	1,000,000
Wolverhampton	250,000
Wolverhampton	400,000
Worthing	525,000
Yarmouth	500,000
Yarmouth	125,000
Yeovil	340,000
Zwolle	200,000
Zwolle	200,000
Zwolle	700,000

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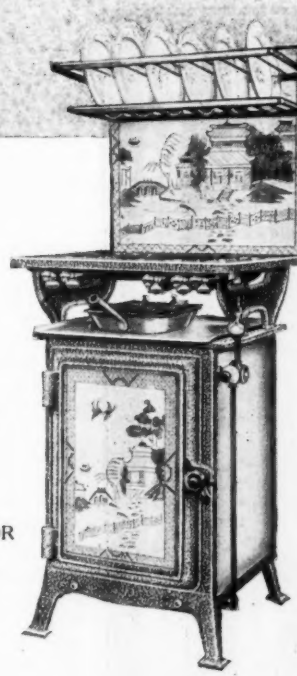

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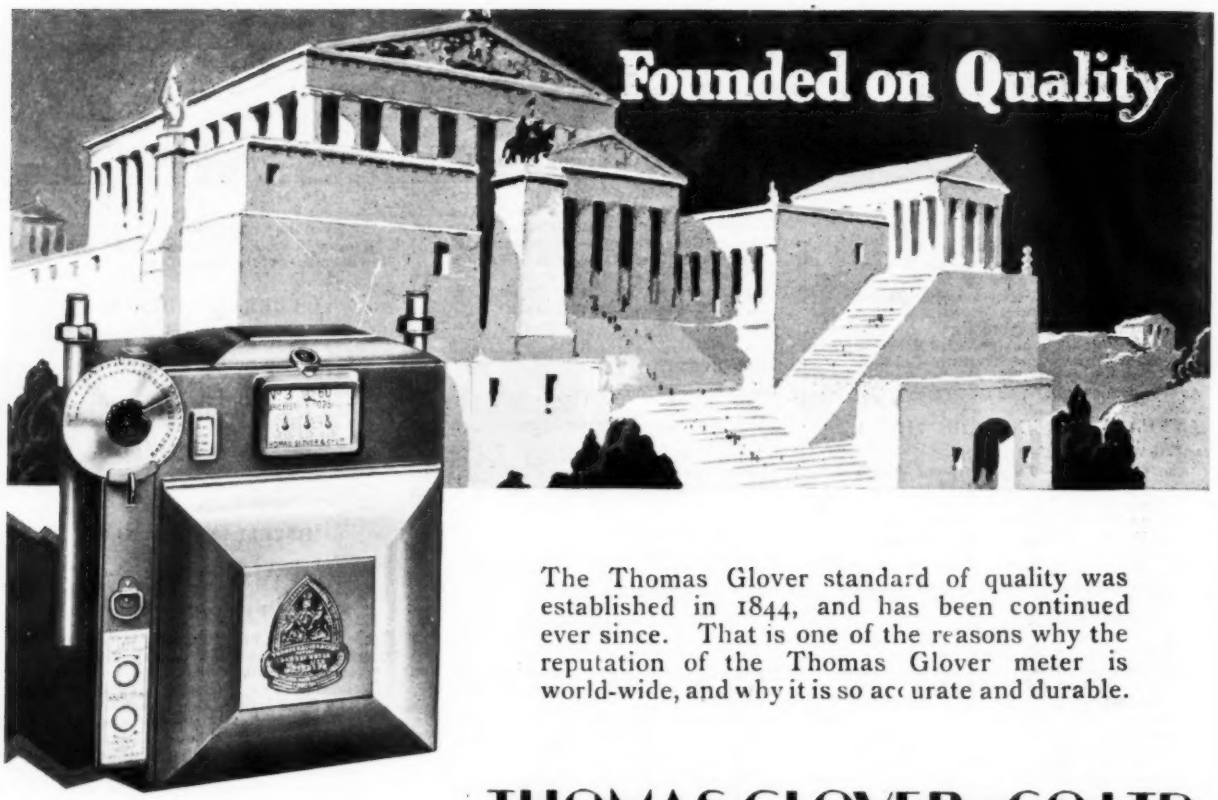

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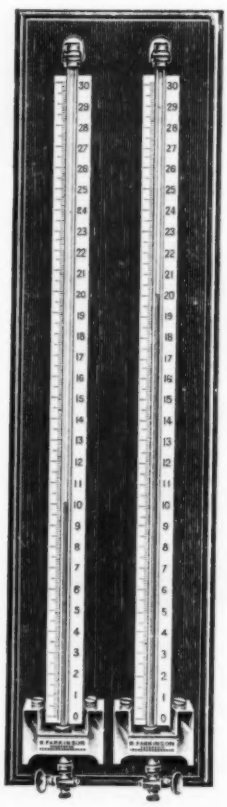

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GAS JOURNAL

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VOL. CXC. No. 3499.] WEDNESDAY, JUNE 11, 1930. [82ND YEAR.

Editorial Notes.

Reflections.

LEEDS has left many memories to all who attended last week's meeting of the Institution, and it is difficult to imagine that any of them can be other than pleasant. It was a big week—full of activity, and of the right spirit. Even the sun roused itself, and resolved to do its best for the occasion by putting in full time. Record acceptances for the meetings, and big gatherings at all the functions were the reward of those who had worked long and arduously to achieve signal success. The highest hopes were realized during the week, and the influence remains.

Times are bad; they may get worse. At any rate, it would be rash to count upon their getting very much better until saner counsels in matters of finance prevail among those who aspire to govern us. No more than a fortnight ago, Sir David Milne-Watson uttered a warning in this respect, when he said that supplying as it does an essential service, it is not surprising that the gas industry "should be among the last to feel the devastating "effects of the acute industrial depression through which "the country is passing. We cannot, however, expect "that this immunity will continue indefinitely. Indeed, "already some have felt the blight, and others can see "it approaching. It behoves us, therefore, to use every "endeavour to counteract the difficulties which appear "to confront us. One of the best methods of doing so "is by reducing the cost of production—by utilizing to "the full and in the most efficient way all the resources "at our command." This should be taken to heart, so that we may all resolve to make still further effort—to brace ourselves for a yet sterner fight. And here it is that the influence of last week's meeting should help us. The vitality, the unanimity—one might even say the enthusiasm—which marked the whole of the proceedings should give us all added determination in undertaking work that lies ahead of us.

We have said that the Leeds meeting of the Institution has left many memories, and it is true. How many old friends did one see—not all, alas, that one would have wished—and how many new friendships were begun! How many pleasant chats were there over past times; how many dreams of brightness for the future! All these, however, have been locked away in the more personal corner of our minds. Let us look for a moment at the meeting as a whole. What were the features which most struck one? In the first place, there was the President, and, secondly, the organization. It is impossible to think of one without thinking of the other. For twelve months Mr. Shapley worked solidly to make his Presidency what it has been—a triumph for himself and a credit to the Institution. Mr. Shapley did not spare himself, and so secured that co-operation from others which is the first step on the road to success that he has traversed. He can look back now, and feel, as we feel, that he has done well. He has, in fact, to give the highest praise, done everything that was expected of him. Help of the utmost value was forthcoming from many quarters, and received due acknowledgment during the proceedings. We will therefore content ourselves here with the one remark that at Leeds Mr. J. R. Willis Alexander, the new Secretary, incontrovertibly won his spurs—or whatever, in a mechanical age, may be their equivalent.

Undoubtedly a Step Forward.

SELDOM have the technical items been so essentially topical. Let us mention three. What problems could be more current than those of benzole recovery in gas-works, of coke oven gas for town supply, and of the waterless holder for gas storage? And let us cite another—not a whit less topical—the question of gas dehydration. Admirable expositions were presented on these subjects by those best fitted to talk about them. Considering them *seriatim*, we had Mr. Hoffert and Mr. Claxton on benzole recovery; Mr. Stewart, who has travelled far to gain a true perspective of the coke oven gas problem, and who is a member of the Gas Light and Coke Company, which is, as our readers are aware, proceeding with the installation of large capacity and thoroughly modern coke oven plant at the largest gas-works in the world; Mr. Prentice, the first to erect a waterless holder in this country, a pioneer and an enthusiast; Dr. Smith, whose powers of collating technical information and arriving at broad and unbiased conclusions are well and widely recognized. Two other matters were discussed; and these too are definitely topical. There was Prof. Cobb on higher education in our industry. His opinions, based upon long association with the teaching and the practical aspects of the gas profession, must, to say the least, carry weight; and there was Dr. Margaret Fishenden extemporizing mathematically about principles of heat transmission which affect both the manufacture and the utilization of gas.

Not only the several items of the programme, but also the arrangements for the conference generally constitute a step forward. We refer particularly to the lull in the technical activities on Wednesday afternoon, to the President's obvious desire, translated almost accurately into effect, to keep the business of the meeting to the scheduled time-table, and to the summarizing of the communications by the authors. "We want summaries"—this, to our mind, ought to be the slogan of conferences of this nature. When every member of the Institution can receive a copy of each paper in advance of the meeting, when every non-member can find each communication *in extenso* in the "GAS JOURNAL," what possible excuse can there be for the author of a paper unduly to delay the discussion? In this direction, last week's meeting was definitely a step forward, though the goal of perfection has not yet been reached.

Of course, there is a host of further impressions, apart entirely from the suitability of the meeting-place, the

splendid hospitality which was extended at all hands, and the number of youthful, fresh, and eager faces which leavened the ranks of the older, and perhaps more sagacious, members. Mr. Prentice's technical entertainment will long be remembered—it has enhanced his reputation as a technical personality. Then there are vivid recollections of the first woman lecturer at an Institution meeting—an example of what can be accomplished if only the stereotyped is sedulously avoided. And finally, the practice of having discussion slips and a limit to the time allotted to those who are sufficiently courageous to inscribe their names thereon is thoroughly to be commended. We repeat that the 1930 Annual General Meeting of the Chartered Institution of Gas Engineers was undoubtedly a step forward.

Personal.

MR. T. REYNOLDS.

Mr. THOMAS REYNOLDS, the Deputy Gas Engineer to the Blackpool Corporation, has been appointed by the Stockport Town Council as the Gas Engineer and Manager for Stockport.

Mr. Reynolds, who is 38 years of age, received his early training in the City of Nottingham Gas Department. He served during the whole period of the war in the Army, going abroad with the 46th North Midland Division, and he later received a commission in the Royal Engineers. On the termination of the war, he returned to his duties at Nottingham, and in 1921 was appointed second Assistant Gas Engineer to the Stockport Corporation, to which town he is returning. He received his appointment as Deputy Gas Engineer and Manager of Blackpool in 1925, and during the past five years has assisted in reconstructing the entire works at Blackpool.

On hearing of Mr. Reynolds's appointment Mr. J. H. Chew, the Gas Manager and Engineer, handed in his resignation with the intention of retaining Mr. Reynolds's services for Blackpool as Gas Manager, and the Gas Committee approved of this foresight on the part of Mr. Chew, but the General Purposes Committee decided to advertise the position when it becomes vacant. Mr. Reynolds commences his duties at Stockport early in July.

Mr. Reynolds is a member of the Council of the Manchester Junior Gas Association, and owing to the poor facilities in the Fylde district for the training of junior gas engineers he started a gas engineers' class at the Blackpool Technical School last winter.

Recently Mr. Reynolds had the members of the Manchester and District Junior Gas Association at Blackpool Gas-Works, when he read to them a paper on the extensions which had taken place in the undertaking during his period of service with the Corporation.

The marriage took place at St. Michael's and All Angels' Church, Polwatte, on April 30, of Mr. Donald Charles Aynscomb Harris, of Messrs. Ford, Rhodes, Thornton & Co., Colombo, and Miss Henrietta Agnes Tyndall (eldest daughter of Mr. J. F. TYNDALL, Manager of the Deal and Walmer Gas-Works).

The Directors of Messrs. Penney & Porter (Engineers), Ltd., of Lincoln (Gas and Constructional Engineers), have appointed Mr. LEONARD R. GRANTHAM, A.M.I.Mech.E., as Managing Director. Mr. Grantham's business career of 25 years has been spent with Messrs. Robey & Co., Ltd., of Lincoln, where he was Chief Estimating Engineer and Assistant Sales Director.

Messrs. Broadhead Constructions, Ltd., announce that the engagement of Mr. James Lawson with them has been terminated, and he has accordingly vacated his seat on their Board.

Obituary.

Mr. ROBERT SHADBOLT, Assoc.M.Inst.Gas E., eldest son of Mr. R. G. Shadbolt, died rather suddenly on Tuesday morning, at 75, Trafalgar Road, Moseley, Birmingham. Deceased, who was 37 years of age, was at one time Assistant Engineer and General Manager, under Mr. W. H. Bennett, at Redhill, and later filled a similar post at Ascot. A little more than three years ago he had an illness from which he never properly recovered, although of late he had shown signs of improvement. These, however, unhappily, proved to be illusory, for he experienced a relapse during last week-end, which terminated fatally. He leaves a widow and one son.

The death has occurred, at the age of 59, of Mr. SNOGDEN, Manager of the gas-works at Crediton. Mr. Snogden had made many friends during his two and a half years' residence in the town, and his death called forth many expressions of regret.

Correspondence.

[We are not responsible for opinions expressed by Correspondents.]

Glycerine—A Study in Chemical Engineering.

SIR,—About two years ago there was in your columns some correspondence relating primarily to the properties of glycerine-water mixtures and their employment as media for the dehydration of gas. It since appears that a plant has been installed on a commercial scale for this purpose, and it has been mentioned in the excellent paper presented by Dr. Smith to the Annual Meeting of the Institution of Gas Engineers.

During the correspondence just mentioned, the advocate of glycerine quoted some data for vapour pressures of these mixtures which were found to be considerably in error. The relevant figures quoted by Dr. Smith from Dr. Colman agree with those advanced by the present writer in the previous correspondence, and although this aspect of the question is entirely disposed of, there are a few points which arise out of Dr. Smith's paper, and the earlier discussion, which merit some further attention.

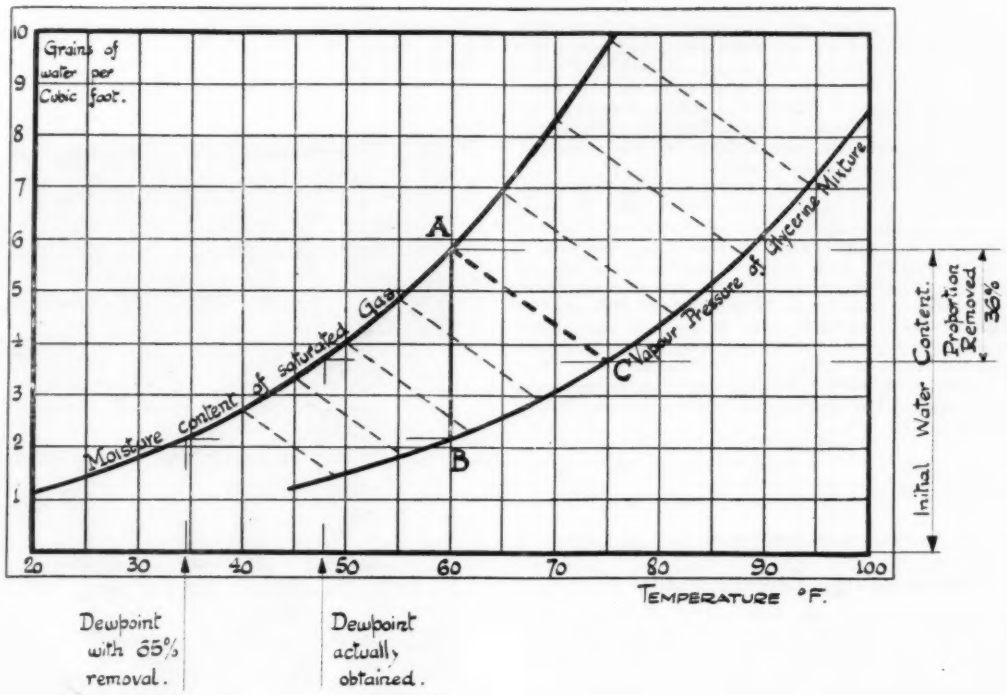
The process described in the paper, which has been also the subject of some trade literature, could not, it was stated by the writer at the time, give a satisfactory result as regards the removal of water vapour from gas, in practice. The best result obtainable with the glycerine plant described in Dr. Smith's paper is about 40 p.ct., whereas claims are made for a removal of 65 p.ct., and even for 75 p.ct.

Some reasons for this unfavourable opinion were advanced, also by the present writer, in his paper on "Purification of Gas" to the World Power Conference in London in 1928. This view is now put forward once more, because in Dr. Smith's paper the statement appears that equivalence exists, under selected conditions, between calcium chloride solution (which has been the preferred medium in all the successful dehydration plants) and the glycerine-water mixtures advocated by your correspondent in the earlier discussion.

It should be mentioned at this point that no working data have as yet been divulged for the plant where glycerine has been tried, and all the information available to the public is contained in this paper, one or two references in our technical journals, and an article in an American publication. The few figures in these latter will be found to be in accordance with the conclusions stated, by the method of evaluation given below.

The results of treating gas by means of a glycerine mixture of the composition given in Dr. Smith's paper, can be worked out by means of the diagram shown herewith. If the point A represents the temperature of the saturated gas entering the washer, the condition claimed as the result of dehydration by glycerine is represented by the point B, whereas the actual result obtained is given by the point C. By reading off either the moisture content in grains per foot, or the dew-point, it will be seen that a large defect exists between the actual and the expected result, the former representing under 40 p.ct. removal.

Some explanation is needed of the diagram, and this is reduced to its simplest form, as follows: Each grain of moisture removed represents so many B.Th.U. of a positive heat effect. Hence the temperature of the surroundings must rise. Each grain of moisture removed per cubic foot of gas gives a temperature rise of the gas of almost exactly 7° Fahr. This heat effect is communicated to the absorbing medium and reduces the possible absorption. The actual result of the contact is that when the rise in temperature of the surroundings carries away the reduced quantity of heat represented by the reduced absorption equilibrium is established. Assuming then that mechanically the contact is efficient, the effect of this rise in temperature is given by the slope of the line AC in the diagram, which has, it will be noted, a slope of 1 gr. = 7° Fahr. The result for any other inlet temperature can be found by following from the corresponding point A parallel to this slope. The ideal of such an absorption process is that the final result



shall be represented by the point B, or an even lower result if such is procurable.

The slight inaccuracies involved in this simplified method of computation are those represented by the heat of solution of liquid water in glycerine, the fact that the latent heat of water vapour varies slightly from the approximate figure of 1050 B.Th.U. used in the calculation, and the variation in the heat capacity per cubic foot of gas at various saturations. There is also the fact to be considered that the stream of absorbent carries away a very small proportion of the heat. These have been averaged, and the error is relatively minute. The maximum effect due to heat lost to or gained from outside the apparatus can be estimated, and it will not affect the results beyond 1° Fahr. either way.

Here it should be stated that these results can be checked by a laboratory experiment under suitable conditions, and have been so checked by the writer, and the absorption effect substantiated.

As a further guide to the reality of this effect, a gas dehydration plant now operating under sub-tropical conditions has been observed to rise in temperature to over 105°, when the gas entered at 80°.

Without any wish to asperse the climatic virtues of Colwyn Bay, it is difficult to accept a representative figure of 75° summer temperature against competing lower figures from other favoured localities. The figure clearly is obtained in the manner stated.

It would be interesting to have a clear statement of how the claims for 65 p.ct. or 75 p.ct. removal can be justified in the light of these considerations.

To summarize the position: If a million feet of gas entering at a saturation temperature of 75° are dehydrated to a dew-point of 50°, a heat evolution of nearly 1 million B.Th.U. per day occurs. This heat is sufficient to raise the temperature of the surroundings to 117° Fahr. What happens to it?

On the other hand, according to the figures quoted from Colwyn Bay, if the gas enters saturated at 60° Fahr., the operating temperature is 75°, and the dew-point result 47°-48° Fahr. This agrees with observation, but is not 75 p.ct. removal, or even 65 p.ct., but only 36 p.ct. removal.

CHAS. COOPER, M.Sc.

W. C. Holmes & Co., Ltd.,
Huddersfield,
June 5, 1930.

A Protest and an Explanation.

SIR,—Some of my friends in the gas industry may have seen, and rightly been astonished by, the appearance in to-day's "Sunday Express" of an article on "Why I read the Bible," flamboyantly displayed under my name, with special reference to the King's Birthday Honours List. Anything in worse taste it would be difficult to conceive, and I should therefore like to record the facts concerning it.

Some three months ago a press agency sought an interview as they were proposing, according to their account to me, to publish in America a symposium of reasons given by public men and women as to why they read the Bible. I gave mine, corrected a typescript sent me, and from that day to this neither heard nor thought any more about the matter. I am now confronted with what looks like an attempt of mine to use the Bible to "boost" myself and my newly conferred honour. A worse example of "modern journalism" it would be difficult to conceive. I am of course registering my protest, but the outrage has been committed and is difficult to efface.

FRANCIS GOODENOUGH.

39, *Holland Street,*
Kensington, W. 8,
June 8, 1930.

Coalite Redivivus.

SIR,—My attention has been called to a long article by Mr. J. H. Brearley in your issue of May 28. Mr. Brearley tries to be both sarcastic and abusive at my expense; he is "left guessing" as to my credentials; I cannot be a "practising technologist" or I would "surely have a little more of Uriah Heap" (nice man!) in my composition, &c., &c. But I am much too old a controversialist to let these bouquets either disturb or flatter me.

Any person of average intelligence might see that the article which Mr. Brearley makes such a stupendous effort to tear to tatters was not written by a "technologist"—practising or otherwise—but by a layman for laymen.

As to my credentials from the latter point of view, Mr. Brearley need not have been "left guessing" if he had turned up "Who's Who;" but perhaps he has never heard of that very useful work of reference. There he would have found that I am Editor of the "Investors' Review" and have previously been City Editor of such papers as the old "Pall Mall Gazette," the "Morning Post," the "Observer," and "Truth." Even such a duffer as myself can scarcely fail to pick up a certain amount of technical as well as financial knowledge after so long an experience.

Now it so happens that I took a very great academic interest in British Coalite, Ltd., from its inception about quarter of a century ago, and was bitterly disappointed that good, honest, enthusiastic, but inexperienced, Mr. Parker fell into such bad financial hands. It is quite true that millions were spent without materially forwarding or improving the low-temperature process, and I never missed an opportunity of denouncing those who involved investors in so much loss.

Two or three years ago my friend the late Prof. H. G. Reid, of Calcutta University (an acknowledged expert on coal carbonization and frequently taken into consultation by the Fuel Research Board), aroused both my curiosity and my scepticism by mentioning that the "Coalite" people were then probably nearer a satisfactory commercial solution of the problem than anyone else. I had for several years regarded the business as a "wash-out"—had, in fact, almost ignored it—and this perfectly unbiassed, expert opinion came to me as a great surprise. I therefore welcomed the first opportunity I had of seeing the works with my own (not entirely untrained) eyes.

I do not intend to be dragged into a discussion of technical details with Mr. Brearley, but I put this proposition to him. Does he really believe that the Works Manager was instructed

to prepare a whole set of false weekly returns for my particular edification, or does he regard me as a fool and a liar? The returns I examined showed not only the amount and cost of the coal carbonized each week, but the wages, repairs, and other works charges, and the destination of every truck of "Coalite" sent out to the distributors. Would any sensible human being reject such evidence? And although Mr. Brearley slithers over it, I specifically pointed out that the works profit was subject to management and other head-office charges.

As to Government support, that is a subject for legitimate diversity of opinion, and I have no objection to Mr. Brearley airing his views any more than I shall be restrained from expressing mine. If it is any comfort to him I may say that I have consistently opposed what I regard as the wasteful and unnecessary exploitation of electric light and power development (with its advisory and central and other boards of bureaucrats) at the expense of the gas industry; but at the same time I am prepared to advocate any rational scheme which promises benefit to the coal industry and a reduction in unemployment. But that I put forward "Coalite" or any other low-temperature scheme as the *sole* solution of the problem is a figment of Mr. Brearley's imagination.

ANDREW STILL,
Editor, "Investors' Review."

30, *Fleet Street, E.C.* 4,
June 5, 1930.

Forthcoming Engagements.

June 14.—SCOTTISH JUNIOR GAS ASSOCIATION (EASTERN DISTRICT).—Annual Outing and Ladies' Day at Dunfermline.

June 21.—LONDON AND SOUTHERN DISTRICT JUNIOR GAS ASSOCIATION.—Summer visit to Eastbourne.

June 21.—WESTERN JUNIOR GAS ASSOCIATION.—Summer outing. Visit to the works of the Plymouth and Stonehouse Gas Light and Coke Company.

June 27.—SOCIETY OF BRITISH GAS INDUSTRIES.—Council meeting in the morning.

June 27.—WAVERLEY ASSOCIATION OF GAS MANAGERS.—Annual meeting in the Goold Hall, St. Andrew's Square, Edinburgh. Address by the President, Mr. David Vass.

June 28.—MANCHESTER AND DISTRICT JUNIOR GAS ASSOCIATION.—Ladies' Day. Visit to Wallasey Gas and Water Works in the afternoon.

July 8.—NATIONAL GAS COUNCIL.—Meeting of Central Executive Board, 28, Grosvenor Gardens, S.W. 1, 2.30 p.m.

July 11.—MANCHESTER DISTRICT INSTITUTION OF GAS ENGINEERS.—Visit to Bolton Gas-Works and Lecture on "The Microscopical Examination of Coal in Relation to the Production of Gas and Coke," by Mr. James Lomax, A.L.S., F.G.S., M.I.M.E., Paleo-Botanist to the Fuel Research Board. The lecture will be illustrated by lantern slides and microscopical preparations.

Aug. 19 and 20.—IRISH ASSOCIATION OF GAS MANAGERS.—Meeting in Dublin.

Sept. 11.—NORTH BRITISH ASSOCIATION OF GAS MANAGERS.—Annual Meeting at Aberdeen.

Oct. 27 to 29.—BRITISH COMMERCIAL GAS ASSOCIATION.—Annual Meeting at Hull and Bridlington.

School Children Visit Birmingham Works.

Some hundreds of scholars from the Birmingham schools have visited the City Gas-Works during the last few days. These organized visits have been arranged officially in order to give the children an insight into the process of gas-making at modern works and into the scientific principles applied in the various stages of gas manufacture. The parties have been divided between the works at Saltley, Nechells, and Windsor Street. In order that the children might derive the fullest benefit from their visit, illustrated booklets had previously been supplied to the appointed schools, and short explanatory lectures had been given by the teachers.

In addition to the process of gas manufacture, the gas-works afford excellent examples of modern plant for the handling and conveying of material. It is felt that the more fully the children realize that there is a definite connection between the elementary laboratory science they learn at school and the actual manufacturing processes in the city, the greater will be their interest in their theoretical studies. The whole process of making, cooling, washing, and testing of town gas is a good illustration of science applied to the daily needs of the citizens.

A better knowledge of the principles underlying industrial processes is claimed to be the best answer to the complaint of monotony that is often levelled against factory and industrial work. It is often ignorance of a process as a whole that renders particular jobs uninteresting, and an intelligent and alert outlook, combined with a modicum of general knowledge, would mean happier working hours and would, no doubt, result in the introduction of many improvements into manufacturing methods.

DELEGATES AT THE SECOND INTERNATIONAL CONFERENCE OF BENZOLE PRODUCERS, HELD IN LONDON ON MAY 30 & 31.

Topical Items.

Oldham Gas Profits.—The Commercial Manager of the Oldham Corporation Gas Committee reported that the Borough Treasurer had ascertained the result of the working of the Gas Department for the past year, which, after payment of interest and sinking fund charges and £4000 to the Borough fund, leaves a net profit of £3228.

City and Guilds of London Institute.—There has been published by John Murray, Albemarle Street, W., at the price of 1s. net (by post 1s. 2d.), the regulations and syllabuses for the examination in chemical, metallurgical, and other allied subjects for the session 1930-31 of the Department of Technology of the City and Guilds of London Institute.

Coke Oven Gas at Leeds.—At a meeting of the Leeds Corporation Gas Committee a letter was received from Messrs. Donald Bagley & Co., Ltd., of London, stipulating the terms and conditions of the Company for supply of gas from coke oven plant proposed to be erected adjacent to Leeds, and it was decided to ask the Company to furnish additional information on the subject.

German Tar Production.—Production of tar at German gasworks last year was 177,384 tons, as compared with 164,342 tons in 1928, 151,514 tons in 1927, and 114,601 tons in 1926. Prices per ton received for the material have, however, been declining rapidly from 82·7 marks in 1927, to 65·5 marks in 1928, and to 45·8 marks in 1929. The fall in prices is attributed to over-production.

Tenders for Rugby Stock Issue.—The tenders for the £15,000 6 p.ct. redeemable preference stock which were offered by Messrs. A. & W. Richards, of 37, Walbrook, E.C. 4, on behalf of the Directors of the Rugby Gas Company, were opened on June 3. The issue was considerably over-subscribed at prices ranging from £105 down to the minimum of par, the average price obtained being £100 7s. 5d. p.ct.

The Hawick Gas Company was registered as a public Company on June 4 in Edinburgh, with a capital of £50,000 in £1 shares, to carry on the business of manufacturers and suppliers of gas in the Burgh of Hawick. The Directors are: Messrs. J. R. Sime, J. Scott, R. H. Lindsay Watson, David Taylor Hardie, Robert Grierson, Walter Thomas Grieve, James John Oliver, Stephen Anderson, and Thomas Elliot Rutherford. Registered Office: 40, Mansfield Road, Hawick.

Cupar Gas Company Centenary.—The centenary of the Cupar Gas Company, Ltd., is to be celebrated by a luncheon and inspection of the works on June 19. The Directors have invited a party of about 70 to be present, among whom will be Sir Arthur Duckham. The Woodall-Duckham plant at the Cupar Works was erected in 1914, and has proved very satisfactory in operation, and has been inspected, it is understood, by representatives of gas companies from many parts of the country.

Plymouth and Stonehouse Company Results.—The accounts of the Plymouth and Stonehouse Gas Light and Coke Company show a balance on the year's work of £34,581, as compared with the sum of £30,282 last year. After the declaration of dividends at the rate of 4 p.ct. on the ordinary stock; 13s. 6d. per share on the additional shares; and 13s. per share on the new shares, the amount carried forward to the current year's accounts is £17,700—an increase of £4300 upon the sum brought in.

Increased Output at Coleraine.—At the meeting of Coleraine Borough Council on June 2, the Gas Committee reported an increased output of 244,700 c.ft. as compared with May of 1929. The total consumption during the past months was 2,719,700 c.ft. A communication was received from the Ministry of Labour stating that they were prepared to give an unemployment grant in respect of the scheme for laying new gas mains and replacing the existing mains with a larger size. The Ministry had previously refused the grant on the ground that the scheme was not capable of postponement.

Gas Coppers at Rotherham.—At a meeting of the Rotherham Corporation Housing Committee, a report was considered from the Housing Manager with regard to the heating of coppers by gas instead of the existing coal fires, and he stated that he had made inquiries from the Gas Engineer, who intimated that the Department were prepared to carry out the work of conversion at the price of 10s. per copper. The Committee decided that in cases where applications are made by tenants of the housing estates for the existing coal-fired coppers to be converted to gas, the Corporation defray the cost, and in the event of applications being received from tenants of the housing estates to instal gas boilers, the Corporation defray half the cost of the removal of the coal-fired copper and the substitution of a gas boiler.

Larger Gas Sales at Omagh.—A loss of £277 5s. 1d. on the gas undertaking for the year ended March 31 last was reported at the last meeting of Omagh Urban Council, the loss being due to a reduction in the price of gas. The gas sold for the year showed an increase of 1,628,000 c.ft. over the previous year.

Waverley Association of Gas Managers.—The annual meeting of the Waverley Association of Gas Managers is to be held on Friday, June 27, in the Goold Hall, St. Andrew's Square, Edinburgh. The President, Mr. David Vass, of Perth, will take the chair at 10.30 a.m., and will deliver his address, which will be open for discussion.

Institution of Heating and Ventilating Engineers.—The summer meeting of the Institution of Heating and Ventilating Engineers will be held at Eastbourne on June 23, 24, and 25, under the Presidency of Mr. E. Reginald Jones. At the general meeting on June 24, a paper will be read by Mr. I. Lubbock, A.M.I.Mech.E., on "A Review of the Present Position of Automatic Heating by Oil Burning."

Discount for Prompt Payment of Accounts.—The Bolton Corporation Gas Committee have rescinded resolutions so far as regards a discount of 2d. per 1000 c.ft. being allowed for payment of gas accounts within 21 days of delivery of account, and have decided that as and from the meter readings for the September quarter's consumption, the prices charged for gas supplies for all purposes be subject to a discount of 5 p.ct. for payment within 21 days of delivery of the account.

Gas v. Electricity in Maidstone Council Houses.

Further Discussion.

Subsequent to the letter appearing in the "Kent Messenger" recently on the subject of gas and electricity in the houses on the Mote Park Estate, Maidstone—reprinted in our last week's issue—further discussion on the matter has taken place at the Maidstone Town Council.

The Housing Committee recommended that the offer of the Maidstone Gas Company to lay mains on the Estate for gas cookers and coppers at a cost of £800, plus 30s. per house for piping at two points (which would mean an increase of rent of 1½d. per week) be accepted, provided that the first tenants be free to have either portable solid fuel coppers or portable gas coppers, without any initial expense to themselves, but there can be no subsequent change except at the cost of the tenant; and that tenants be free, after 12 months' occupation, to have electric cookers in place of gas cookers if they pay any expense entailed.

Mr. Lyle did not agree that the Council or the tenants should pay to have the gas conveyed to the houses. Why should the tenants have to pay an extra 1½d. a week all their lives for a gas main which belonged to the Gas Company?

Alderman Foster Clark said the real truth was that if they gave the Gas Company the lighting they would put the mains in free, but gas lighting was excluded. The Council had always taken the view that electricity for lighting was healthier and cleaner. There had been a good deal of controversy over the cost, but the report of the Government Fuel Research Committee stated that the relative cost of gas was 2½ times as much as coal, and electricity was 5½ times as much. Inquiries of the tenants on the Mangravet Estate showed that the cost of gas and electricity worked out about the same, because the tenants found it too expensive to use much electricity.

Mr. Wells said that they were proposing to pay £800 to the Gas Company, which was a subsidy to the gas consumer. The Electricity Committee were prepared to put in their mains free, so that it meant if they adopted the resolution they would not be getting the cheapest possible houses. The only way to get the cheapest possible house was to try the electric house and a gas house without a subsidy. Tenants should have fuel coppers if they desired them. People should be given the choice of gas or electricity at the lowest figure.

Dr. Gibb pointed out that the Electricity Committee would not lay the cables for nothing. Who would pay—the town, the tenant, or the electricity undertaking? The Gas Company said the mains would cost so much and they were going to charge for them, whereas the Electricity Committee did not say they were going to charge for the cables.

Mr. Egerton Martin hoped the recommendations would be carried, as it was the best thing which could be done in the interests of the tenants. No pressure would be brought on anyone to use either gas or electricity, and the Gas Company would be free to canvass.

A Thousand Years' Service.

Retirement Record for Gas Industry Veterans.

A record number of employees of the South Metropolitan Gas Company have just retired on pension under the co-partnership insurance fund scheme. The fund has now 640 pensioners on its lists.

Of the 34 co-partners now retiring, two are sixty-eight years of age, four are sixty-seven, seven are sixty-six, and twenty-one are sixty-five. Their average length of service is nearly thirty years, and the aggregate service, taking the group as a whole, over one thousand years.

Included in the list are men from all sections—store repairers, labourers, fitters, complaints men, blacksmiths, stokers, firemen, porters, inspectors, &c. The figures are regarded as eloquent testimony to the healthy conditions of service in the industry.

The Year's Work at Stafford.

The Gas Committee of the Stafford Town Council in their report on the accounts for the past year state that the gross profit for the year was £11,921, compared with £18,723 in the previous year, a decrease of £6802.

This was mainly due to increased expenditure on coal of £900, together with other items totalling £2251, to which had to be added a decrease in revenue from the sale of gas of £4787, and residuals £2764, giving a total loss of income of £4451.

After deducting from the gross profit £8799 for charges for service of debt and income-tax, there was a net profit on the year's working of £3121.

The appropriation account now stood at £5401, of which £2000 had been allocated to the renewals fund, and £3401 carried forward. The reserve and renewals fund at the beginning of the year was £11,950, but expenditure on retorts, mains, and meters had reduced the figure to £1638.

Gas made for the twelve months amounted to 367,474,100 c.ft., compared with 369,677,000 c.ft. the previous year, a decrease of 2,202,900 c.ft.

Barrow-in-Furness Show Increased Sales.

At the monthly meeting of the Barrow Town Council on Monday evening, June 2, Councillor J. V. Holland, Chairman of the Gas and Water Committee, pointed out that from the accounts and report for the financial year ended March 31 last, it would be seen that there was again a very satisfactory increase in the output of gas, amounting to 29,679,000 c.ft., equal to 8·4 p.ct. over the previous year's figure.

"Practically the whole of this extra consumption," he proceeded, "is again due to the increased demand for domestic purposes through the prepayment meters. The total quantity of gas sold amounted to 383,445,000 c.ft., and it is pleasing to be able to record that during the past seven years the consumption of gas has increased from 279,511,000 c.ft., or by 37 p.ct."

Continuing, Councillor Holland stated that during the year 133 new consumers had been added, and 133 additional cooking stoves had been placed out on hire. The number of consumers was now 15,228, and 12,167 cooking stoves were out on hire. With regard to the accounts, notwithstanding the extra quantity of gas sold, the income from this source was only up by £421, due to the fact that the price of gas was reduced by 6d. per 1000 c.ft. from Oct. 1, 1928. This meant that the price for the whole of the twelve months under review was 3s. 9d., while for the previous year it was 4s. 3d. for the first half and 3s. 9d. during the latter half.

Coke produced £376 more than the previous year, but unfortunately the amount received from the sale of tar and liquor was less by £2593, due entirely to reduced prices. Sulphate of ammonia was down by £222. Regarding the expenditure side, with the exception of oil and coke for the manufacture of carburetted water gas and renewals contributions, which showed increases of £1430 and £62 respectively, every item of expenditure was considerably less—coal by £503; wages, salaries, and materials for manufacture by £235; distribution by £202; repairs by £352; public lamps by £22; rates and taxes by £175.

After setting aside the sum of £11,273 for renewals, the gross profit for the year amounted to £13,465. Interest and sinking fund contributions absorbed £14,425, less bank interest, £109, leaving a net loss on the year's working of £851. While this small loss had resulted it should be borne in mind that items amounting to £2702 had been charged to the renewals fund, which, if the practice of former years had been followed, would have been placed to capital account. The loss of £851 was equivalent to ¾d. per 1000 c.ft. of gas sold. They owed a great deal to Mr. Diamond, their Engineer and Manager, for his handling of the business throughout.

Gas *v.* Electricity for Heating.

Question Discussed at Smethwick.

At a meeting of the Smethwick Town Council on June 4 a discussion took place with regard to the rival merits of gas and electricity in connection with the heating of the new clinic on the Firs Estate. The Health Committee recommended that electricity be adopted.

Mr. Salmon moved the reference back of the recommendation with instructions to obtain prices for alternate systems. He argued that in a county borough like Smethwick, with its municipal gas undertaking, with electricity a huge monopoly as it was to-day, it would be far better from the ratepayers' point of view to take advantage of their own property and use gas rather than encourage, at great expense, a monopoly over which they had no control. There was no evidence of the success of heating by electricity, and he did not think the Council should have to pay for experiments of that kind.

Other members supported the proposal on hygienic grounds. Alderman Pinkney complained that the Council had no information as to the price. He objected to being bound by the principle of heating by electricity because they could not depart from it, and no other system could be put up against it.

Alderman Willets said gas was the most profitable agency for heating. He described the recent decision of the Council to heat the new Uplands School by electricity as a huge experiment or gamble, and he urged that they should have some experience of that experiment before they went any further.

Eventually, the reference back was carried by 13 votes to 9.

Advantages of Carburetted Water Gas.

A new and enlarged edition of "Carburetted Water Gas Installations" has been published by Messrs. Humphreys & Glasgow, Ltd.; and our readers will doubtless be interested in this booklet, which states that about two-thirds of the gas manufactured by town gas undertakings in the United States and one-sixth of the town gas used in Great Britain is carburetted water gas, the annual consumption of which is about 350,000 million c.ft.

Excluding American work, 793 sets of Humphreys & Glasgow carburetted water gas plant, and 111 sets of H. & G. blue water gas plant have been (and are being) installed, with a total daily capacity exceeding 760 million c.ft. Including the work of the firm's American colleagues, the United Gas Improvement Company, 1998 sets have been (and are being) constructed, with a total capacity exceeding 2090 million c.ft. per diem. These carburetted installations, in 200 working days, would produce all of the carburetted water gas used annually in the world.

The United Gas Improvement Company, originally organized in 1882 to acquire and exploit the Lowe master-patent for carburetted water gas manufacture, now own control or share in ownership and control of American public utilities worth over £300,000,000 sterling—including, among many gas undertakings, the administration of the municipally-owned Philadelphia gas supply of 20,000 million c.ft. per annum. All patents, improvements and experience in gas plant and processes accruing from the operations of this great American Company and its contracting subsidiary United Engineers and Constructors, Inc., revert immediately to the exclusive use of Messrs. Humphreys & Glasgow in Europe.

The booklet puts forward the following collateral advantages of carburetted water gas: Saving in first cost of works; small ground space occupied; reduced wear and tear; availability and flexibility; saving in coal-gas repairs and storage capacity; increased prices for coke; independence of coal supply; greater yield of coal gas; independence of labour; instant control of illuminating and calorific power simply by adjusting the oil supply; prevention of naphthalene deposits; permanence; improved combustion; and small sulphur content.

Value of Collateral Advantages.

It is evident, states the booklet, that a comparison of the ordinary book-keeping accounts, when coal gas and carburetted water gas are made concurrently, does not disclose the financial benefit resulting from the auxiliary manufacture of carburetted water gas—inasmuch as this auxiliary effect is to reduce the cost of the coal gas in many ways. Not only do these collateral economies go to the credit of coal gas in the accounts, instead of being credited to the carburetted water gas, to which they are due, but the expenses by which they are accomplished (including the coke used by the process at the enhanced price due to the use of the process, and the costs of intermittent and emergency working, enrichment, &c.) are charged against the carburetted water gas—thus doubly vitiating the comparison of costs shown by the accounts, and doubly disguising the true benefit of the process.

Commercial and Industrial.

Stock Market Report.

[For Stock and Share List, see later page.]

There were no signs last week of any improvement in conditions on the Stock Exchange, and most markets continued distinctly dull and uninteresting. Even British Funds, which recently have been the one bright feature, suffered a reverse during the week, though a recovery was made towards the close.

In spite of the general depression Gas Stocks and Shares continued the even tenor of their ways, and there is nothing of importance to report. Prices, it is true, are in several instances a trifle less as compared with this time a year ago, but for some weeks past most of the changes have been in an upward direction. There were several increases last week. Imperial Continental rose a further 5 points to 365; and each of the following gained 2: Primitiva 4 p.ct. debenture is 95½, South Suburban 5 p.ct. debenture to 96½. Tottenham 5½ p.ct. preference to 98½, and the Wandsworth 5 p.ct. preference and 5 p.ct. debenture to 89½ and 96½ respectively. Sutton 5 p.ct. debenture and Tottenham ordinary each gained 1. The only fall was that of the European £10 shares by 1 to 13.

The accounts of the Plymouth and Stonehouse Gas Light and Coke Company for the year to March 31 show that the balance standing to the credit of the net revenue account is £34,582 against £30,282. The Directors are recommending a dividend for the half-year to March 31 at the rates of 8 p.ct. per annum on the ordinary stock, 13s. 6d. per share on the additional shares, and 13s. per share on the new shares—the same rates as the previous year. After providing for this, the carry-forward is increased from £13,401 to £17,700. The report states that the quantity of gas sold has again increased, and that a record number of appliances was sold during the year. The Company has applied to the Board of Trade for a Special Order to enable them to raise additional capital to meet the increase in business, and also for powers to extend their area of supply. The present price of the Company's ordinary stock is 108½, and on the dividend for the year gives the high yield for this class of security of £7 7s. 5d. p.ct. The stock changed hands last year at 113; but as with many other gas securities it is closely held, and a parcel rarely comes into the market, so that a standing order will be necessary if a purchase is contemplated.

Coal Markets.

Not only in all districts in this country, but throughout the coal-fields of Europe, there seems to be a complete slump, and conditions are reminiscent of some of the worst depressions of other times. Pits everywhere are working very short, but even so there is not nearly enough trade to make the outlook anything like settled for the greatly reduced production. Prices are down, but it seems there is no demand at any price.

Durham gas coal is sharing in the general depression, and prices for prompt loading are subject generally to negotiation. Wear specials are nominally 15s. 9d. to 16s. f.o.b., and bests 15s. 6d., with seconds round 13s. and 13s. 3d. Coking coals are no better than about 13s. 3d. for best qualities. The official export price for Yorkshire screened gas is 15s. 6d. to 16s. 6d. f.o.b.

Perhaps the steadiest spot in the whole market is gas coke, of which supplies are by no means in excess, and the price remains at abou. 21s. 6d.

Current Sales of Gas Products.

The London Market for Tar, Tar Products, and Sulphate.

LONDON, *June* 10.

The prices of tar products are unchanged.

Creosote for export is 6d. to 6¼d. per gallon f.o.b. Pitch is 47s. 6d. per ton f.o.b.

Pure toluole is 2s. 3d. per gallon; 95/160 solvent naphtha, about 1s. 5d. per gallon; pure benzole, about 1s. 11d. per gallon; and pyridine bases, 3s. 9d. per gallon.

Tar Products in the Provinces.

June 10.

The average prices of gas-works products during the week were: Gas-works tar, 20s. to 25s. Pitch—East Coast, 46s. f.o.b. West Coast—Manchester, Liverpool, Clyde, 46s. f.o.b.* Toluole, naked, North, 1s. 7¼d. to 1s. 8¼d. Coal-tar crude naphtha, in bulk, North, 9d. to 10d. Solvent naphtha, naked, North, 1s. 3d. to 1s. 3½d. Heavy naphtha, North, 1s. to 1s. 0¾d. Creosote, in bulk, North, liquid and salty, 3¾d. to 3¾d.; low gravity, 1¾d. to 1½d.; Scotland, 3¾d. to 3¾d. Heavy oils, in bulk, North, 5¾d. to 6d. Carbolic acid, 60's, 2s. 2d. June, 2s. to 2s. 1d. July/December. Naphthalene, £12 to £14. Salts, £5 to £5 10s., bags included. Anthracene, "A" quality, 2½d. per minimum, 40 p.ct., purely nominal; "B" quality, unsaleable.

* All prices for pitch are now quoted on the basis of f.o.b. In order to arrive at the f.a.s. value at any port, it will be necessary to deduct the loading costs and the tolls whatever they may be.

Tar Products in Scotland.

GLASGOW, *June* 7.

There is no change to report in market conditions throughout the week. Refined tar is still being sent out in considerable quantities, and motor benzole orders are more frequent.

Pitch.—The export value is nominal at 47s. 6d. to 50s. per ton f.o.b. Glasgow. Home orders are scarce with quotations easy at about 47s. 6d. per ton f.o.r. makers' works.

Tar.—Orders are quite frequent, and the position is not unsatisfactory. Price is steady at 3¼d. to 3¾d. per gallon in buyers' packages at makers' works.

Creosote is unchanged. B.E.S.A. specification is 3½d. to 4d. per gallon; low gravity, 3d. to 3½d. per gallon; neutral oil, 3d. to 3½d. per gallon—all f.o.r. works.

Cresylic.—Few orders are passing, but quotations are meantime unaltered. Pale 97/99 p.ct. is 1s. 8¾d. to 1s. 9¾d. per gallon; dark 97/99 p.ct. is 1s. 7¼d. to 1s. 8¼d. per gallon; pale 99/100 p.ct. is 1s. 11¼d. to 2s. 0¼d. per gallon—all at makers' works in bulk.

Crude naphtha is about 4¼d. to 4¾d. per gallon according to quality and district.

Solvent naphtha.—A fair demand continues, and 90/160 is not less than 1s. 2½d. to 1s. 3½d. per gallon. 90/190 is 1s. to 1s. 1d. per gallon.

Motor benzole continues steady in value at 1s. 6¼d. to 1s. 6¾d. per gallon f.o.r. with more orders passing.

Pyridines are very dull. 90/160 is 3s. to 3s. 3d. per gallon.

Benzole Prices.

The following are considered to be the market prices at the present time:

	s. d.	s. d.	
Crude benzole . . .	0 10 to	0 11	per gallon at works
Motor ,, . . .	1 5½ ,,	1 6½ ,,	,, ,,
Pure ,, . . .	1 10 ,,	1 11 ,,	,, ,,

Contracts Open.

Coal.

The Warrington Gas Department invite tenders for the supply of coal. [See advert. on p. 788.]

The Rochdale Gas Committee invite tenders for the supply of gas coal. [See advert. on p. 788.]

The Pontefract Gas Department invite tenders for the supply of gas nuts. [See advert. on p. 790.]

The City and County Borough of Belfast invite tenders for the supply of gas coal. [See advert. on p. 790.]

The Barnoldswick Urban District Council Gas Department invite tenders for the supply of coal. [See advert. on p. 788.]

Condensers.

The Barnoldswick Urban District Council invite tenders for the supply of a set of cast-iron vertical water cooled condensers. [See advert. on p. 788.]

Cookers, Fires, &c.

The Warrington Gas Department invite tenders for the supply of cookers and fires. [See advert. on p. 788.]

Gasholder Repairs.

The Pontypridd Urban District Council invite tenders for repairs to a gasholder. [See advert. on p. 788.]

General Stores (Vitriol, Refractories, Oils, Paints, Iron and Steel, &c.).

The Warrington Gas Department invite tenders for various stores. [See advert. on p. 788.]

The County Borough of Rochdale invite tenders for the supply and delivery of vitriol. [See advert. on p. 788.]

Lighting Goods (Mantles, Fittings, &c.).

The Warrington Gas Department invite tenders for the supply of lighting goods. [See advert. on p. 788.]

Meters.

The Warrington Gas Department invite tenders for the supply of meters. [See advert. on p. 788.]

Oxide of Iron (New and Spent).

The Warrington Gas Department are inviting tenders for new and spent oxide. [See advert. on p. 788.]

The County Borough of Rochdale invite tenders for the supply of new oxide and the purchase of spent oxide. [See advert. on p. 788.]

Pipes, Valves, &c.

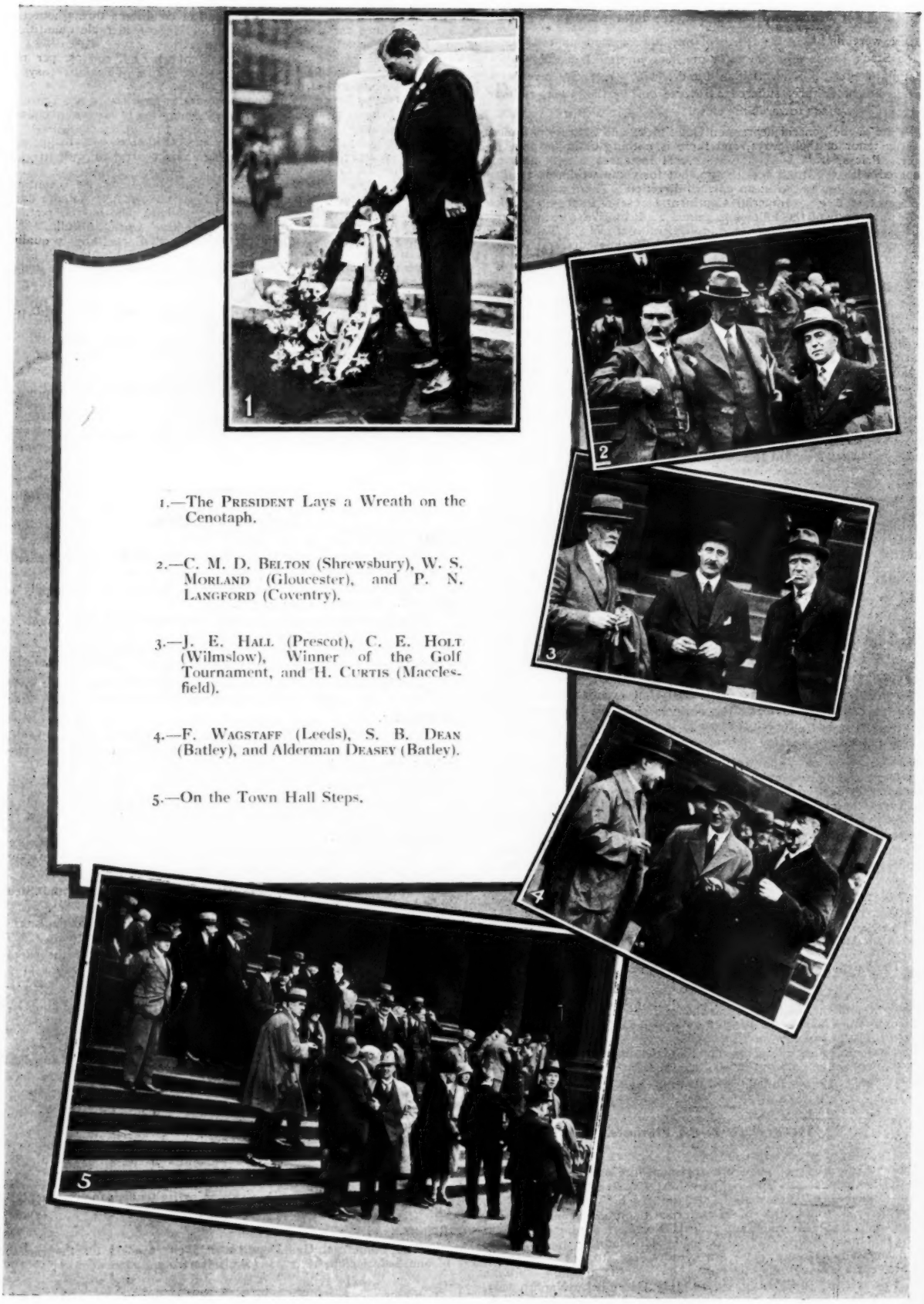
The Warrington Gas Department invite tenders for the supply of pipes, &c. [See advert. on p. 788.]

Retorts.

The Pontefract Gas Department invite tenders for the renewal of one bed of eight retorts. [See advert. on p. 790.]

The Stoke-on-Trent Corporation Gas Committee recommend the acceptance of the tender of Messrs. R. & J. Dempster for the erection of a waterless gasholder at a cost of £33,154.

The Burton-on-Trent Corporation Gas Committee have decided to purchase a new turbo-blowing set for the water gas plant at a cost of about £600, and tenders are being invited.



1.—The PRESIDENT Lays a Wreath on the Cenotaph.

2.—C. M. D. BELTON (Shrewsbury), W. S. MORLAND (Gloucester), and P. N. LANGFORD (Coventry).

3.—J. E. HALL (Prescot), C. E. HOLT (Wilmslow), Winner of the Golf Tournament, and H. CURTIS (Macclesfield).

4.—F. WAGSTAFF (Leeds), S. B. DEAN (Batley), and Alderman DEASEY (Batley).

5.—On the Town Hall Steps.

INSTITUTION OF GAS ENGINEERS.

Review of Proceedings

at the ANNUAL GENERAL MEETING in the Town Hall, Leeds, June 3, 4, and 5, 1930.

PRESIDENT - CHARLES S. SHAPLEY, M.I.MECH.E.

In the numbers attending, in the welcome presence of enthusiastic youth and enthusiastic age, in the crispness of the discussions, this unusual meeting constituted a record. It was unusual in its place, and in its general arrangement. Every innovation contributed to accelerating technical business and enhancing social pleasure. In brief, the 1930 Conference was a memorable success in all its aspects.

C. S. SHAPLEY,

Engineer and General Manager of the Leeds Gas Department.

Mr. Shapley was educated at the Taplow Grammar School and the Torquay Technical School, and served his articles at the Torquay Gas-Works, under Mr. Robert Beynon. He was Assistant at the Nuneaton Gas-Works under Mr. George Helps, and was afterwards Consulting Engineer to Messrs. Schulz & Comins (now Messrs. W. A. Scott & Co.), from which office the following works were operated: Annfield Plain (including Annfield Plain, Kyo, and Dipton), Brixham, Crediton, Debenham, Hungerford, Soham, and Whitchurch. He was Works Manager of the Neepsend Gas-Works of the Sheffield Gas Light Company, following which he became Manager of the Southend-on-Sea Gas Company. He is a Past-President of the Manchester District Institution of Gas Engineers (1926-27), and also a Past-President of the Association of Public Lighting Engineers (1925-26). He is Chairman of the West Riding District Executive Board of the National Gas Council, and the West Riding Joint Regional Industrial Council, and Deputy Chairman of the West Riding District Committee of the Federation of Gas Employers, and the Yorkshire Commercial Section of Gas Undertakings.

Our Story Begins.

Flowers and fairy lamps; a member of the Institution, Mr. Robinson, of Harrogate, playing the great organ in the Town Hall, Leeds. No, it is not a concert. It is the opening of the Meeting of the Institution on Tuesday morning. Judging from the numbers present when the Lord Mayor of Leeds, Councillor N. G. Morrison, J.P., in his Chain of Office, rose to offer a welcome to the famous industrial city, an onlooker might well have imagined the gathering an audience for one of the musical festivals for which Leeds is renowned. The

FRANK H. ROBINSON, Assoc.M.Inst.C.E., M.Inst.Gas E.,
Whose recitals on the Victoria Hall organ were so impressive.

illusion was not long to last, for, from the time the Lord Mayor gave his welcome to the time when, on the following Thursday afternoon, the last vote of thanks had been accorded, the meeting was characterized by its crispness, by the excellent manner in which the President kept to the scheduled time-table, and by the general business-like tone of the proceedings.

Enter, a Knight.

First of all, the Lord Mayor announced that Mr. Goodenough of yesterday was Sir Francis Goodenough of to-day, which news was greeted with prolonged and sincere applause. . . . And so to the official welcome.

"I understand," said Councillor Morrison, "that you are visiting Leeds in honour to your President, our Gas Engineer, of whom the Corporation of this City thinks a great deal. As for the programme of the conference, I certainly think it reflects credit upon those responsible for it, for both business proceedings and social intercourse are necessary and desirable. I congratulate the Institution on their choice of President; by their choice they have honoured not only Mr. Shapley himself but also the City of Leeds. Mr. Shapley, by his consistent ability and energy, has attained a position as one of the leading engineers of your great industry."

"Your Institution," continued the Lord Mayor, "is the supreme technical organization of the gas industry, and the City of Leeds, which is profoundly interested in your industry, is naturally profoundly interested, also, in the work of your Institution. Whatever developments there may be in other directions concerning the provision of light, heat, and power, there will always be room for the employment of gas."

To the King, on His Birthday.

Following the Lord Mayor's welcome, the new Secretary of the Institution, Mr. J. R. Willis Alexander, announced the dispatch of a telegram to His Majesty the King. This was in the following terms:

> The Members of the Institution of Gas Engineers, to which your Majesty was pleased to grant a Royal Charter last year, assembled at their Sixty-Seventh Annual General Meeting in the Town Hall, Leeds, send dutiful greetings and loyal congratulations on your Majesty's birthday.

From Overseas.

Then came the President's welcome to the Overseas Representatives—Mr. A. P. Brill (representing the American Gas Association), New York; Mr. C. H. Carder, Rio de Janeiro; Mr. Aage Christensen (Danish Association of Gas Engineers), Copenhagen; Mr. Bengt Dahlman (Swedish Association), Stockholm; Dr. B. Friedman; Mr. A. F. P. Hayman (Belgian Gas Association), Antwerp; Dr. W. Mayer, Stuttgart; and Dr. H. Schutte (German Association of Gas and Water Engineers), Bremen.

Announcement was also made that congratulatory cables expressing good wishes for the success of the conference had been received from the Canadian Gas Association, the Australian Gas Association, the French Gas Association, the Italian Gas and Water Association, the Norwegian Gas Association, the Swiss Gas and Water Association, and the Gas and Water Association of Czecho-Slovakia.

A reply on behalf of the Overseas Delegates was made by Mr. Aage Christensen, who, in a brief speech, wished present and future success to the Institution.

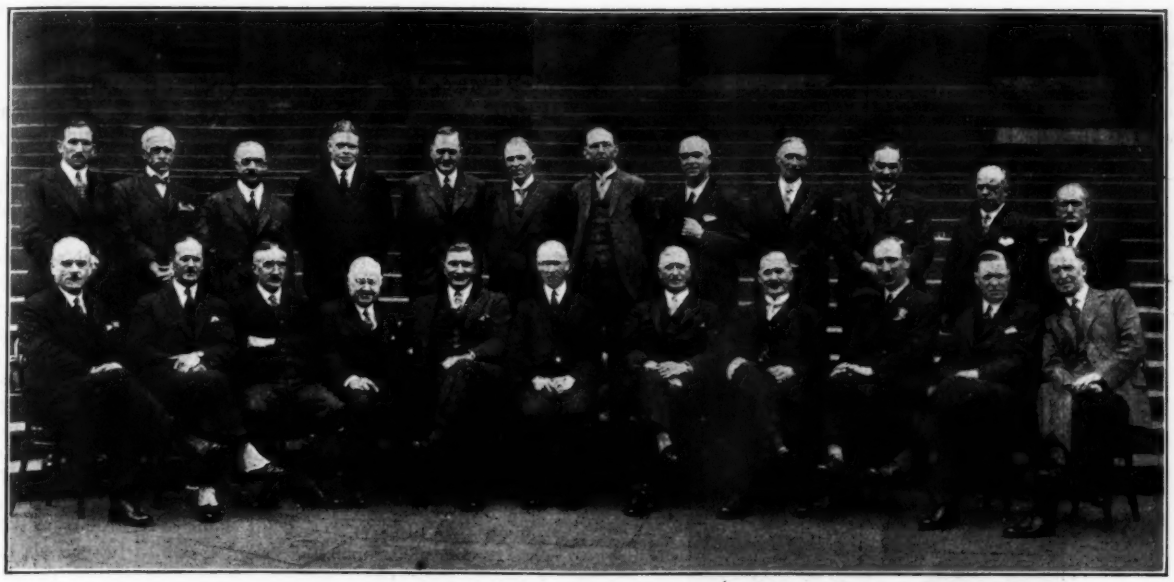
Presentation to Mr. Walter Hole.

The minutes of the last annual meeting in London, the annual report for 1929-30, and the accounts for 1929 having been taken as read, Sir Francis Goodenough was called upon formally to present, as Chairman, the Report of the Gas Education Committee. He did not discuss the report, but referred to the presentation to Mr. Walter Hole in recognition of the work which he had done as Organizing Secretary of the Education Scheme of our Industry. "The proposal that we should make some small recognition of the great services which Mr. Hole has rendered," said Sir Francis, "was received with great enthusiasm, particularly by the young men of the industry, for whom Mr. Hole had done so much during the years he was in charge of the Education Scheme. We are going to ask him to accept—and it is his selection—a first-class wireless set, so that at his home in Torquay he may keep in touch with the world. I should like, on behalf of the Education Committee and of all the subscribers, to ask his acceptance of a letter, which reads as follows:

> "Your many friends in the gas industry ask your acceptance of a wireless set as a small memento of the great services you so willingly and ungrudgingly rendered to the cause of education in the industry during the years you acted as Organizing Secretary to the Education Scheme of the Institution of Gas Engineers, and hope that you may live long to enjoy its use.
>
> (Sgd.) CHAIRMAN OF THE GAS EDUCATION COMMITTEE.

"As the Chairman of the Committee which has had the benefit of Mr. Hole's services, I add my personal thanks to him for the enormous help that he has rendered." The letter was presented to Mr. Hole, amid applause.

Thanking the members of the Institution and of the Education Committee for their memento of his "seven years' hard," Mr. Walter Hole, whose ascent to the platform was the signal for an enthusiastic reception, said how happy these years had been. He had enjoyed the wise and statesmanlike guidance of the Chairman of the Committee; he had been happy in the expressions of appreciation which he had received so many times from young men in the industry whom he had been able to assist; and he had been delighted to receive, twelve months ago, when it was known that he was relinquishing his position as Secretary, many letters from heads of technical institutions expressing their appreciation of the relations which had existed between the Education Committee and those institutions during the time the Scheme had been



MR. JOHN TERRACE AND THE CHARTER COUNCIL.

in operation. "The Scheme now," concluded Mr. Hole, "has attained its real place in the life of the industry."

The resolution for the adoption of the report having been seconded by Mr. J. E. Blundell, and carried unanimously, Mr. James Campbell and Mr. A. E. Mottram were appointed Scrutineers of the ballot for the election of officers and members of the Institution.

Progress of the Education Scheme.

The Report of the Committee, though it contains no news of a startling nature, indicates that the Education Scheme of the Institution now rests on more secure foundations. The modifications lately introduced to meet the requirements of the isolated student have enhanced the solidity and broadened the base of these foundations; there is an awakening of enthusiasm among the students. As for the Major Courses, the number of entries of internal candidates shows practically no increase, but the revised regulations ought to effect marked progress in this direction. Much good would be done—and this applies particularly to students of gas supply—if gas engineers and managers encouraged their employees to enter upon regular courses of study, called for reports on their progress, and took into account, when fixing salaries, granting promotion, or filling vacancies, both the results and the fact that the young men are seeking to improve themselves by education. There were many more entrants in Minor Grouped Courses in Gas Supply Practice and in all three grades of Gas Fitting.

The entire administrative and secretarial responsibility of the Scheme is now in the hands of Mr. Alexander, the Secretary of the Institution.

Award of Medals.

The next item on the programme was the presentation of the Institution's Medals. With the exception of Mr. Harrison (for whom Mr. J. W. McLusky deputized) all those who had won awards were able to receive them from the hands of Mr. Shapley. The awards were as follows: Institution Gold Medal, 1929, Frederic G. Gorman, Assoc.M.Inst.C.E., M.Inst.Gas E., for his paper on "The Incident of the Peak Load," which he read at the annual meeting of the Institution last year. Institution Silver Medal, 1929, J. Frederick Harrison, M.Inst.C.E., M.Inst.Gas E., for his paper, "Notes on Carbonizing Plant at the Dawsholm Gas-Works, Glasgow," read on Sept. 12, 1929. Institution Bronze Medal, 1929, A. G Grant, M.Sc., Assoc.M.Inst.Gas E., for his paper on "Some Aspects of the Carburetting Process in Water Gas Manufacture," read on Nov. 22, 1929. Institution Silver Medal, 1928, Joseph Poulson, M.Inst.Gas E., for his paper, "Continuous Vertical Retort Practice at Oldbury," read on March 29, 1928. Institution Bronze Medal, 1928, Frederick C. Smith, Assoc.M.Inst.Gas E., for his paper, "Some Aspects of Corrosion in Gas Supply Practice," read on March 30, 1928.

Following this, the President formally introduced to the members the new Secretary of the Institution, who was given a hearty reception.

The Democratic President.

At this stage in the proceedings Mr. Shapley delivered his Presidential Address, which thoroughly interested his vast audience. In his opening remarks he struck the middle C of his year of office by referring to the new move which has been made whereby any member of the Institution, irrespective of his financial position, may hold the office of President. Mr. Shapley will be remembered as the Democratic President. The gratitude of the industry is due to him, too, for the example of tireless energy which he has displayed in visiting every District Association throughout the country, and also for inaugurating the autumnal meeting of the Institution, specially devoted to discussion of research work. In regard to the last autumn meeting, we thank Mr. Shapley for his bouquet.

Mr. F. G. GORMAN.
(Institution Gold Medallist, 1929.)

Matters New.

The granting of the Royal Charter has acted as a catalyst to the activities of the Institution and to the zest of its members.

We now have armorial bearings resplendent with rampant bulls and lions, leaves argent, fess sable and gules, and other peculiar things (*vide* the "JOURNAL" a fortnight ago); and all members of the Institution will shortly receive a certificate which has been designed by Mr. F. D. Marshall and which will embody the armorial bearings.

Then, during the year Mr. P. F. Holmes and Mr. D. M. Henshaw have endowed a Scholarship in memory of the late Mr. William Cartwright Holmes, of Huddersfield. Worth

J. R. Willis Alexander, M.A., LL.B.
The Institution's Secretary.

£170 per annum, the William Cartwright Holmes Scholarship will enable a student to take a course of study at the University of Leeds, in preparation for a responsible position in gas engineering. Also, Mr. P. C. Holmes Hunt, on behalf of himself and his brothers and sisters, has endowed, in memory of his father, a Charles Hunt Memorial Medal in the Diploma in Gas Engineering and another in the Diploma in Gas Supply. Both medals will be awarded annually.

On a Delicate, yet Vital, Problem.

Mr. Shapley, not forgetful of the Lincoln fiasco a short time ago, spoke on the all-important question of salaries. Can the Institution take steps to secure the adequate payment of its members in their capacity as engineers, managers, and assistants of gas undertakings? There are two alternatives. One is to place an embargo upon the appointment by asking members not to apply; the other course is to draw up a scale of salaries which, having the common consent of both employers and employees, would be observed as being in the nature of a national award. An embargo, said the President, has the disadvantage that its general observance cannot be ensured, while the legal position is not without its difficulties. The negotiation of a scale of salaries would not be an easy matter, having in mind the diverse conditions which exist in different works and the fact that there are company owned as well as municipally owned undertakings. Assuming that a scale is agreed upon and can be effectively enforced in all cases, it still has to be remembered that such a scale suffers by reason of the fact that what is intended to be minimum remuneration would, more often than not, be regarded as a maximum as well. However, the situation is being carefully watched and considered by the Institution. To our mind, this very fact is of benefit—people mind their "p's and q's" when they become aware that their "just and righteous" actions are liable to be the subject not only of criticism, but also of ridicule.

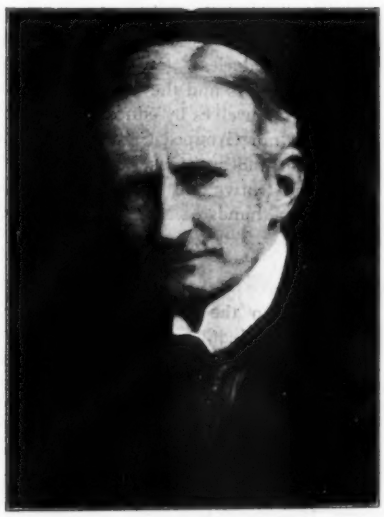
The vote of thanks to the President for his address was in the hands of Mr. H. E. Copp and Mr. John Terrace, who respectively proposed and seconded the resolution. Mr. Copp spoke of the President's virility, outspokenness, and boundless energy, while Mr. Terrace emphasized how much the members of the Institution owed to the City of Leeds for their kindness in making it possible for the President to give of his services so freely during the year, and also for the hospitality extended to them for their present conference.

A Happy Coincidence.

It was very fitting that the next item on the programme should be Professor Cobb's contribution indicating the interdependence of the Institution and the University of Leeds, for it is an interesting coincidence that the first annual meeting of the Institution following the granting of its Charter should be held in the city where the first Chair in Gas Engineering was established in a British University. Prof. Cobb's paper is largely a record of the invaluable research undertaken, jointly with the Institution, at Leeds, but it also contains certain generalizations with which we are in hearty and complete agreement. As Prof. Cobb said, it is an unchallengeable proposition that the stage of development reached by an industry, or the professional status of its responsible leaders, managers, and technical experts, may be gauged from the standard of general and professional education which it has the courage and sagacity to demand in its recruitment from the youth of the day. This proposition is consequential upon another of equal validity that the progress of any industry or profession will be largely dependent upon the extent to which it succeeds in attracting to its service first-class human material. These propositions are partly from stress of circumstances much more clearly recognized as true than ever before, and the industry or profession which is low in its educational and intellectual demands, or slow in its recognition of merit or services by promotion or other reward, stands little chance of that survival which is reserved for the fittest.

The Young and Elastic Mind.

There can be no two opinions regarding the view of Prof. Cobb that a student who has had the opportunity and time, during a full University course, to bend his energies while his mind is young and elastic to saturating himself with the scientific principles of his industry will find it possible to acquire practical and detailed information comparatively easily and quickly on entry into industrial life, and to understand and initiate. On the other hand, if that period of rigorous scientific training is omitted, the acquisition of its implied knowledge and scientific habit of mind in after life can hardly ever be successfully undertaken. The demands in detail of daily duty are too great to permit of it, and continued mental concentration upon a line of thought which is not obviously con-



Prof. J. W. COBB, C.B.E.

nected with a problem of the moment calls for a sustained effort which few can, or will, make.

A Partnership Which Must Not Be Dissolved.

The working of gas processes and appliances is much more thoroughly understood nowadays than it was twenty or even ten years ago; efficiencies have been raised and economies effected; and the industry is able to look forward to the future

A VERY HAPPY INSPIRATION.

with confidence in its ability to develop rationally and along lines indicated by scientific knowledge and principles. We agree with Prof. Cobb that it is not too much to claim some share for the collaboration of the Institution and the University in the responsibility for this record of progress. This partnership simply must not be dissolved.

From time to time we hear fathers complain that the world is overburdened by young men who desire a reasonable living. Every profession, they say, is hopelessly overcrowded. Of course, all these fathers have worthy—more often than not, brilliant—sons. In view of all this, it cannot be too widely known, as Mr. Shapley remarked, that the number of entrants for training as gas engineers and fuel technologists does not correspond with the increasing demand for qualified men. The promising boy leaving school should know that there is such a profession as that of gas engineer or fuel technologist, and that the prospects offered to the right type of man, properly trained, are excellent.

On the Subject of Apathy.

Dr. E. W. Smith, C.B.E., who set the ball rolling in the discussion on Prof. Cobb's paper, in clear, incisive tones, and as an old research worker—probably one of the earliest—at Leeds University, queried whether the courses in Gas Engineering at the University are subjected to review from time to time. The rapid development of both the science of gas engineering and the gas industry itself led him to mention this. "We want," he said, "to ensure that these courses are applicable not only to men of to-day, but to men of five years hence." Such a review, he suggested, might well be undertaken by the industry, as well as the University, at reasonable intervals; and in his own opinion the courses ought to include some training in economics and practical engineering. And he wondered whether the recent granting of the Royal Charter would render it necessary to modify the courses to make them fit in with the higher standard of engineering now necessary. Dr. Smith maintains that our industry is not nearly enthusiastic enough about these valuable courses. "What," he asked, "can be done by the Institution—apart from offering fellowships, and so on—definitely to encourage men to be trained as gas engineers?"

Later in the discussion Sir Arthur Duckham emphasized Prof. Cobb's statement that, in spite of the fact that he has his students fully booked up a year or more before they finish their courses at the University with jobs at good remuneration, relatively few men come forward for training as gas engineers. Is this, he asked, due to bad publicity, or is it simply that young fellows have not the means to enable them to devote four years of their lives at the appropriate time? If it is a case of bad publicity, let the Institution see what can be done. If it is a matter of shortage of funds, why not arrange for greater support, perhaps by developing a further series of scholarships. And at all costs, in the training itself, let us encourage imagination.

Mutual Advantages.

In a speech of great charm and clarity, Prof. Smithells, told the members how much it has meant to the University of Leeds to be associated with the gas industry, and he delicately pointed out the peculiar advantages which the industry has gained by that association. There will be general agreement with Prof. Smithells' opinion that research on the problems of industry gains immeasurably when associated with a university institution, because of the great breadth of study with which it comes into contact there. "The gas industry," he said, "profits in a very clear, distinct, and unique manner by its contact with a university centre. Prof. Smithells spoke of men of great learning but of great inefficiency in the qualities which a university cannot provide. He concluded his remarks on a note of optimism by expressing his belief that Prof. Cobb may look forward to a better response, and to increasing numbers of young men coming to be trained.

The praises of Prof. Cobb and Prof. Smithells were sung by Sir Francis Goodenough, Mr. Thomas Hardie, and Mr. Botley; and there was a general chorus of accord.

Down to Technical Business.

The afternoon session on Tuesday was devoted to consideration of the communication by Mr. C. F. Broadhead, of Melbourne, on the preparation of a new road binder made from tar. The author was not present to submit his paper in person, but the task was admirably carried out by Mr. H. E. Bloor, of York. The paper indicates the complexity of the gas engineer's work, and it demonstrates how he examines an obstacle—no mean one in this particular instance—finds the correct recipe for the "dynamite" which will remove the obstruction in the path of progress and profits, and ignites the fuse without fear.

Ten years ago, the author—who at that time was Engineer to the Brisbane Gas Company—found himself "up against it" in the matter of tar disposal for road-making. Verticals had

superseded horizontals at the works, and the vertical tar produced found no favour with the municipalities. "The wells became full, tar had to be used and sold as fuel, as far as the limited demand existed, and the surplus was simply wasted." Mr. Broadhead sought a solution to this problem. He examined the "Duratar" process of the Australian Gas Light Company, who had experienced similar trouble, but he did not adopt it. He does not tell us why.

Decline and Fall of the Tar Market.

Then, in 1925, Mr. Broadhead was appointed to the Metropolitan Gas Company of Melbourne. Conditions there were pleasant enough—the revenue from tar was equal to 7d. per 1000 c.ft. of gas sold. Then came a decline. In 1920, 12 p.ct. of the gas was made in continuous verticals; in 1929, the figure was 65 p.ct., and in the latter year tar brought in 2·83d. per 1000 c.ft. of gas sold. In the meantime the importation of bitumen increased enormously.

The author then toured the world to investigate the "marked deterioration of the tar as a road binder as the percentage of vertical retort gas increased." He came to England, and discussed the matter; and in his paper he gives us the impression that in 1927 he went empty away. However, in America, his attention had been concentrated on the damage done to meter diaphragms by the gum-forming compounds—indene, styrene, and the like; and on his return to Melbourne, he set in motion an investigation to ascertain whether it would be possible to polymerize to gums the higher boiling unsaturated hydrocarbons in the vertical tar, and thus render it more suitable for road purposes. Polymerization takes place very slowly unless accelerated by some catalytic agent, and oxidation products of unsaturated hydrocarbons form excellent catalysts. Various aldehydes were tried, but formaldehyde and acetaldehyde were found to give the best results.

The Birth of "Bitural."

The manufacture of "Bitural" was then commenced. Mr. Broadhead outlines the procedure. "Bitural" is prepared by intimately mixing 10 gallons of formalin and 5 gallons of 0·880 ammonia with 1000 gallons of tar, and digesting at 150° Fahr. for eight hours, when formaldehyde condensation products are formed *in situ* with the phenols, cresols, xylols, &c. At the termination of this period heated air is either passed through or over the tar, until the desired consistency is reached, when the unsaturated hydrocarbons, in the presence of formaldehyde oxidation and condensation products and in the presence of air, are converted to gummy polymers. During this stage the temperature is gradually raised to 380° Fahr. If it is decided to pass the air through the tar, then the temperature is kept lower. The author states that the process is not as rapid as is distillation, but, owing to the low working temperature, the cost of plant is considerably less, and, the operation being almost automatic, the labour cost per gallon is less. The output per unit of capital invested is greater.

The claims made for "Bitural" are that the unsaturated hydrocarbons are polymerized under control before the tar is placed on the road; the tar acids which aid polymerization are "fixed" by formaldehyde condensation; when the oils eventually evaporate a plastic material remains behind on the road, and not a brittle, friable pitch; the presence of plastic gummy substances instead of oils decreases the vapour pressure of the material, thus retarding the evaporation of the oils present. "These four factors combine," states the author, "so to improve the nature of the tar that the longevity of the road is increased to such a degree that it is confidently expected that tar will be restored to its old status in road construction."

The Proof of the Pudding.

And now a few words about the practical progress of "Bitural." The plant at West Melbourne is to be increased to a capacity of half-a-million gallons a year, owing to the encouraging reception which has met the product, even in quarters previously definitely hostile to distilled tar; the Colonial Gas Association has erected a plant in Melbourne capable of making about 250,000 gallons per annum; a leading firm of tar distillers in New Zealand intend to adopt the process; and a distilling firm in Melbourne are going to erect a plant with an ultimate yearly capacity of 1 million gallons. The cost of treatment in Australia, with a plant of 125,000 gallons per annum capacity, is given as 2d. a gallon, and the author considers that the cost in England would be 1d. He also gives a financial estimate for a plant capable of producing 1 million gallons of "Bitural" a year.

Essentially an Australian Paper.

Mr. H. E. Bloor, of York, who presented the paper, made it clear at the outset that his task was one of friendship and not one of agreement. His summary of the paper was admirable; in a few words he indicated that conditions which may apply in Australia certainly do not obtain in this country, and that the author was dealing with circumstances outside the ordinary scope of our experience here. The idea underlying Mr. Broadhead's statement linking up the large reduction in the value of tar with the alleged reduction in the quality of tar, said Mr. Bloor, is "entirely erroneous." With this opinion we agree without question. Mr. Broadhead's paper is essentially an Australian paper, albeit, as such, an excellent one; and he is to be congratulated on developing a process which has enabled him to compete successfully with bitumen. Moreover—and we like this—the paper is definitely an original one. The main point is this, however—that because a vertical tar does not fill the bill in Australia it by no means follows that it does not fill the bill in England. It does; and we were glad to hear Mr. Copp's observations on this matter. Mr. Copp was grave, but his gravity was justified and his contribution to the discussion was most valuable. He deplored the author's omission of any attempt to explain the difference between the climatic conditions in this country and in Australia, and he also deplored the author's attribution that the fall in the prices of tar in this country is largely due to the supposed inferiority of vertical tar. The decline, said Mr. Copp, is "due principally to heavy production, German competition in a free market, and reduced creosote exports to America." To our mind, the last-named cause has perhaps the greatest bearing on the problem. Another point of importance stressed by Mr. Copp was the item of cost. In a nutshell, the "Bitural" process would not pay in this country.

Coals and Tars.

Different coals produce different tars. This was emphasized by Mr. W. M. Carr, whose remarks were tuned in to the wavelength of those of Mr. Copp, except for a slight oscillation at the close, when he suggested that in some instances the author's process would repay careful study in this country. Mr. H. D. Madden stood at attention in the ranks with Mr. Bloor and Mr. Copp, and in that position told the meeting some very interesting facts. Not for him the idea that vertical tar produced from British coals is unsuitable for road-making. The author's trouble, he said, is not with vertical retorts, but with Australian coals and the Australian climate. Dr. E. W. Smith fenced skilfully with the Road Board specification for tar as opponent, and was equally successful in patting it on the back as a friend. "There is," he remarked, "a very big gallonage of tar being use to-day which is giving at least as much satisfaction as the very best horizontal tar, but which has a specific gravity below that set by the Road Board's specification. . . . In the case of vertical retort tars which do not comply with the specific gravity test, however, it is possible, by a suitable simple distillation and blending—blending with its own constituents—to produce a road tar which does comply with the specific gravity test. That is so in nearly all cases, but not quite all. Where there is difficulty, bitumen might assist, and where bitumen will assist, 'Bitural should assist.' That is where 'Bitural' should be of some help." Dr. Smith concluded his remarks by calling attention to the need for independent research on tar. Mr. L. H. Sensicle expressed his interest in the "Bitural" process technically, and also his doubt in the process commercially; and he went on to explain in a few words a process with which he has been associated for making road tar. Briefly, this is a method for producing a tar with a very low tar acid content and a low naphthalene content by extracting the tar from the hot gases. "Tar acids and naphthalene pass forward and do not enter the tar to anything like the extent they would do norm-

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ally—perhaps to less than half the normal extent. The tar is thus suitable for road purposes; its viscosity is nearly right, and it has only to be dehydrated." Altogether, it will be gathered, Mr. Broadhead's paper had a fairly rough passage in British waters.

Good-bye to the Old Institution.

Preceding the morning session on Wednesday, there was an Extraordinary General Meeting of the old Institution, at which a special resolution was passed that the Institution should be wound up voluntarily. The Solicitor to the Institution, Mr. G. E. Shrimpton, explained the purpose of the meeting, and the proceedings were purely formal. Mr. J. R. Willis Alexander was appointed liquidator.

A Message from the King.

The session of the new Institution then commenced, the first business being the President's announcement that the King had replied to the Institution's telegram of good wishes in the following terms:

> The King commands me to convey to you and all those associated with you in your message his sincere thanks for this expression of good wishes which His Majesty much appreciates.
>
> STAMFORDHAM.

Election of Officers and Council.

This was the first item on the programme, and the President, in announcing the report of the Scrutineers, mentioned that the ballot had been a very full one—a fact which augurs well for the future of the Institution. The following elections were made for 1930-31:

President.—Mr. H. E. Copp (British Gas-Light Company, Hull).

Senior Vice-President.—Mr. J. H. Canning, O.B.E. (Newport).

Junior Vice-President.—Mr. Ralph G. Gibson (Liverpool).

Auditors.—Mr. Arthur E. Broadberry (London) and Mr. Alfred Morland (London).

Hon. Secretary.—Mr. W. E. Price.

Ordinary Members of Council.—Mr. Charles M. Belton (Shrewsbury), Mr. William M. Carr (Stretford), Mr. William E. Dean (Exmouth), and Mr. W. B. McLusky (Halifax).

To the Power of Theta.

Dr. Margaret Fishenden followed in bright mood in the rôle of mathematical interpreter, and the Institution heard much about $\frac{ag\theta l^3c^2}{k^2}$. Shorn of some of its alarming (at first sight) symbols, however, the paper which she presented reads pleasantly; and as further acquaintance with the mathematical symbols rendered her remarks clearer and clearer, their ***raison d'être*** soon became apparent. She explained that her intention was not to mystify, but to simplify; and it can be said without hesitation that she achieved her object most nobly. She aroused interest in the means of solving many problems concerned with processes involving heat transfer.

The object of her contribution, she said, was simply to indicate certain methods of correlating and applying available data, particularly in regard to convection. Having pointed to the difference between heat loss by convection and heat loss by radiation, the author spoke at some length about emissivity and selected emitters—explaining, ***inter alia,*** why white clothing is cool in summer, and how different paints affect radiation from hot surfaces—and then discussed natural convection, mentioning that the rate at which heat is removed from the surface of a body by natural convection currents depends upon its size, shape, and inclination to the vertical, as well as upon the nature of the surrounding fluid and the temperature difference. Also, the heat transfer may be modified through the interference of other surfaces with the convection streams. Thence to evaluation of this rate of heat loss.

The author then considered forced convection, and heat transfer between a tube and a fluid flowing through it, between a plane surface and a fluid flowing across it, and through a wall or partition. There followed the method of correlating convection data, based upon the principle of similarity, which enables scattered results obtained under different conditions to be incorporated in a few curves of relatively wide application. The final section of the contribution is concerned with the application of similarity curves.

Oliver Twist, and Others.

Everybody was obviously delighted with the manner in which Dr. Fishenden dealt with her paper in summary. She brought life and vigour to bear upon her remarks. She was a tonic; not a sedative. Mr. C. A. Masterman, who for some time has been delving into the mysteries of flue pipes, came forward, like Oliver Twist, to ask for more, for, he said, there is a real need for co-ordination of knowledge and information on this important subject. He expressed surprise that Dr. Fishenden had not mentioned the use of crumpled metallic foil as a lagging—a material which shows very low thermal conductivity and low thermal capacity combined with resistance to relatively high temperatures. He then went on to mention, as he did a few months ago in a paper before the Institution of Heating and Ventilating Engineers, the marked temperature gradient across the sectional area of a flue. What one has to do, he said, is to prevent the development of local cool areas, since condensation may here occur even though the mean flue gas temperature is well above the critical limit.

Dr. MARGARET FISHENDEN.

To some extent this danger has been avoided by the introduction of elbows, which disturb the cool shell and so prevent these local cool spots. Mr. Masterman also spoke of heat transference, stating that where flame contact is undesirable or impracticable, short-wave radiation from incandescent refractory material leads to accelerated heat transfer. "Assuming that the normal relatively low rate of heat transfer is due to lamina flow," he remarked, "even though conditions are nominally turbulent, the aim on plane heat transfer surfaces should be to plough-off the cooler layers of gases which have given up their heat and replace them with hot gases. Following this principle I have found it possible to increase the efficiency of a simple water heating unit from under 50 p.ct. to over 70 p.ct. without in any way affecting the heat transfer surfaces themselves."

Mr. Gilbert B. Haworth spoke of the difference in emissivity between aluminium paint and a true metallic surface. This is doubtless due to the properties of the medium with which the paint is mixed. This medium is transparent to visual rays and so allows the aluminium to be seen, but absorbs heat rays, and, therefore, acts to some extent as a "black body." He also gives an example of the practical application of the theoretical principles dealt with in Dr. Fishenden's paper. A certain hotel, he said, not far from Leeds was heated by means of hot water radiators. The black appearance of the radiators and pipes conflicted with the scheme of decoration, and they were replaced by highly polished ones. The management was delighted to find a saving in boiler fuel as a result of

THE CONFERENCE PHOTOGRAPH

the change, but the real effect was *not* greater efficiency, but a slightly reduced heat output from the polished surfaces owing to their lower emissivity.

Both Mr. J. W. Wood and Mr. H. J. Hodsman sought further information on the factor of viscosity. Mr. Haworth said that the loss of heat by convection is plainly influenced by the character of the surface; while Mr. Hodsman remarked that it is a very useful step forward which has been made in recent years to bring numerous curves into one focus by the application of the principle of similarity. We arrive at a single curve with which a wide range of experimental data can be tested. These dimensional calculations are a sort of mathematical sleight-of-hand for getting round difficulties which cannot be explained by straightforward means.

The application of the principles dealt with in the paper to gas-works problems was dealt with by Mr. H. Hollings. The section upon natural convection, he observed, has a very direct bearing upon those heat losses from retort settings usually included with radiation losses in an over-all coefficient of cooling. He also mentioned that the principles enunciated by Dr. Fishenden under the heading of "Forced Convection" are directly applicable to the design of water-cooled condensers and also to the design of coolers for ammoniacal liquor or the washing oil used for benzole recovery.

Dr. Fishenden's brief acknowledgment of the discussion was as spirited as her summary. She intimated that she would reply in a written communication.

An Appeal.

At this stage Mr. C. Valon Bennett made an appeal, in most eloquent terms, for the Benevolent Fund. He told those present that the total membership of the Institution is about 1400, whereas only about 400 contribute to the Benevolent Fund; and he emphasized that the Management Committee would be very pleased to receive any sum of money from 5s. upwards.

A New Process Established.

The last item of Wednesday's technical business was Dr. E. W. Smith's paper on the dehydration—or, rather, partial dehydration—of gas, which the author regards as one of the most important advances which have been made on the technical and commercial sides of our industry in recent years. As about fifty gas undertakings, from the largest to the smallest, have adopted the calcium chloride process, it is obvious that Dr. Smith is not alone in his opinion. The communication is a report of what has been done, as distinct from a theoretical dissertation, and it is the outcome of a questionnaire which the author addressed to the undertakings that are distributing dried gas. Anyone still in doubt about the virtues of the dehydration process will find the facts set out by Dr. Smith convincing proof that fears are groundless. Gas drying has come to stay.

Pros and Cons.

Of course, there are disadvantages to the process of partial dehydration—more expensive and more complicated gas manufacture, for instance. But the advantages far outweigh the disadvantages. The pros and cons of the question are admirably scheduled in the paper. During recent months we have had the opportunity of dealing with these in our columns, thanks to the publication of results by those who have operated plants at Portsmouth, Weston-super-Mare, Ware, Neath, and other places; hence there is no need for us to dwell on this matter. Dr. Smith, however, puts forward, in a list of twenty-three virtues, a few advantages on which the limelight does not often shine—for example, elimination of the need for such thorough purification from cyanogen compounds; the oil film becomes more permanent, and hence more effective; the cost of distribution is lowered, due to the smaller inert content of the gas; where steaming is carried out, it may be pushed further without loss of the declared calorific value; larger returns from the gas made, due to a reduction in the number of meters registering slow; and reduction in the cost of boosting gas bought in bulk.

Cost of Partial Dehydration.

Considering this all-important phase of the subject, Dr. Smith did not confine himself to one process only, though it may here be remarked that, as yet, there is only one glycerin plant in operation in this country. Calcium chloride and glycerin, said the author, are equally efficient as dehydrating agents; and though the loss of glycerin in the process represents a greater cost than is experienced in the case of calcium chloride plants, "it is nevertheless not of sufficient magnitude to warrant undue consideration being given to this aspect." With the calcium chloride process the range of costs is from 0·22d. to 0·72d. per 1000 c.ft., depending on the size of the installation. But the costs are negligible when compared with the savings consequent on dehydration—to say nothing of better service to the consumer. On this subject,

[*Photo. London Panoramic Company.*

ON THE TOWN HALL STEPS.

Dr. Smith's extracts from replies to the questionnaire are of great interest. The cost of dehydrating gas by a compression process alone is higher than for dehydration by an absorbent; hence, said Dr. Smith, "such methods do not come into consideration except when the gas is to be distributed under pressure. The success of the operation depends also, in a high degree, on the temperature of the available cooling water, and with increasing temperature of the cooling water the costs are raised to a disproportionately large extent."

Among several other points about the dehydration process which ought to be taken into consideration when assessing the costs of operation, one is of singular interest. In some cases it has happened that the two halves of a naphthalene scrubber were formerly both in use; but as a result of the increased efficiency of naphthalene scrubbers in absence of water, it has become possible to employ the first half of the scrubber as the dehydration unit, and the second half as the naphthalene extraction unit without impairing the efficiency of naphthalene removal.

Doubts Removed.

The first speaker in the discussion was Mr. Belton, of Shrewsbury Though his dehydrating plant has been working for less than two years, he has found that dust troubles have now practically disappeared. As for syphon pumping costs, the estimate of savings which he gave in reply to the questionnaire will be greatly exceeded in practice. To-day service complaints in his area of supply are negligible, naphthalene complaints are unknown, and complaints as to "no light," "bad pressure," and so on are very occasional. Mr. Knowles, of Messrs. Kirkham, Hulett, & Chandler, Ltd., put in a plea for the use of glycerin as dehydrating medium, pointing out that the loss of this absorbent per unit of gas treated has been halved in the latest plant compared with that at Colwyn Bay. Mr. Cooper, of Messrs. W. C. Holmes & Co., Ltd.—to whom later Prof. Cobb paid a tribute for his pioneer work—explained that gum or resin difficulties occur on districts where dehydration has not been practised. The same thing was mentioned by Mr. Sensicle, who referred to an interesting case in regard to syphon pumping of a coke oven gas main serving a large gas undertaking. The liquid contained hydrocyanic acid, but this was thought of no importance. The syphons were pumped out on to the fields through which the main passed. Shortly after this, certain cows breathed their last; and the only solution to the difficulty was to recommend the drying of the gas before it left the coke oven plant. Mr. Jackson, of Neath, expressed his conviction that the savings which follow the installation of gas drying plant are far greater than most people realize; and he emphasized the point that dry gas means better service to the consumer—a vital matter in view of keen competition. The question of corrosion was dealt with by Mr. B. R. Parkinson, who suggested that from this aspect the presence of oxygen in either saturated or dried gas is highly objectionable. A reply to this was forthcoming from Dr. A. Parker. It is, he said, necessary to have an acid solution of some kind in contact with the metal if there is to be corrosion, and this acid solution can be avoided by preventing the deposition of water. In regard to the use of glycerin, he asked

Dr. E. W. SMITH, C.B.E.

whether this absorbent, after rapid distillation, takes up various organic volatile substances from the gas, and loses, in some measure, its dehydrating properties or changes its viscosity. Altogether an excellent discussion.

Meeting of the Benevolent Fund.

Prior to the commencement of the general session on Thursday morning, there was a meeting of the contributors of the Benevolent Fund, when the President announced that Mr. Frank Harding Jones had forwarded his second contribution

of £100 to the Fund. Mr. Jones and Mr. J. E. Blundell were elected to the Committee of Management.

A Wealth of Valuable Statistics.

This brought us to the topical paper by Mr. E. G. Stewart on "The Functions of Coke Ovens," which, eagerly awaited and enthusiastically received, is certainly the best-balanced exposition we have yet encountered of the position of the coke oven as a coke-making and gas-making unit attached to collieries, to steel plant, and to gas-works. Our readers are aware that the Gas Light and Coke Company are installing at their Beckton Works a Koppers combination installation of a capacity of 1200 tons per day, arranged to form, if ultimately extended, the nucleus of two 2400 tons per day units. This is an item of the liveliest interest, and we will confine our brief review of Mr. Stewart's comprehensive contribution, which provides a wealth of valuable statistics, to an epitome of his remarks on this aspect of the functions of the coke oven—merely observing, in passing, that he shows that, by suitable location and balancing of works, the coke oven engaged in the production of coke for iron and steel manufacture need have no surplus gas disposal problem.

In the United States, at least 24 gas undertakings operate coke oven installations which have an annual carbonizing capacity of over 6 million tons of coal. Last year American gas undertakings sold 50,000 million c.ft. of coke oven gas. Similar progress is taking place in Canada and in Europe. In

Mr. E. G. STEWART.

Europe, 18 gas undertakings are operating 830 ovens which can carbonize 2¼ million tons of coal annually. These developments, be it noted, are recent—within the last five years or so. Hence there would appear a *primâ facie* case for the general use of coke ovens by gas-works. Mr. Stewart shows, however, that, as far as this country is concerned, the possibilities of coke ovens on gas-works are extremely limited. The coke market here is different from that abroad; and the adoption of coke oven plant by gas undertakings abroad has been largely influenced by the fact that the domestic consumer favours a dense coke, in contrast to the demand for a more easily combustible coke in England.

Coke Ovens *versus* Continuous Verticals.

The capital cost of coke ovens for gas-works, per ton of coal carbonized per day, is greater than that of a large continuous vertical retort bench; the ground space occupied, on the basis of therms per sq. ft., is much greater with coke ovens; the maintenance costs are less with coke ovens. Of the three systems of carbonization—coke ovens, horizontals, and continuous verticals—the last-named is the cheapest gas-making proposition; and Mr. Stewart observes that, as vertical coke finds a ready market, the absence of the coke oven from British gas-works equipment is not difficult to explain.

To secure the advantages of coke oven plant, it is essential to have a large installation and to operate it continuously as a base-load plant. And there are only four gas undertakings in Great Britain—Glasgow, Birmingham, the South Metropolitan, and the Gas Light and Coke—large enough to work a 1200-ton per day plant continuously. The reason why coke ovens are being erected at Beckton is because the Gas Light and Coke Company have at this station a definite outlet for the type of coke produced, a suitable site, together with an output giving the ability to instal ovens of sufficient size to compete in cost with vertical retorts, rather than by any definite conviction, at present, as to the future of coke ovens as gas-works plant. In brief, the coke oven as a gas-works carbonizing plant in this country would seem to be of interest to only the eight largest undertakings, who together treat some 37 p.ct. of the total coal carbonized by the industry, and to have been rejected already by several of them; it cannot compete with continuous vertical retorts unless of over 1000 tons per day capacity; it requires a ground space greater than any existing gas-works carbonizing plant; and it produces a coke which would need special care in marketing, especially if the undertaking produced coke of an entirely different character, such as vertical coke.

Almost an Exit?

The outcome of the discussion was to the effect that, except in special circumstances, the coke oven plant is unsuitable for gas production on a gas-works. Certainly, said Sir Arthur Duckham, it is not a paying proposition for a gas-works to instal coke ovens unless they can obtain a superior price for their coke; and he stressed the point that if we in the gas industry pay the same attention to our coal as do the coke oven people, then the price of our coke will remain high. At the same time, there is a distinct lesson to be learnt from the coke oven people—for our summer load we ought to devise means of decreasing our production per unit of plant instead of allowing the plants to go cold, giving rise to troubles from contraction. Mr. G. M. Gill called the attention of the meeting to the small ovens, holding charges of from 4 to 6 tons, which are in use at gas-works in the United States. He thinks that such plant is really very suitable for gas-works. An excellent and valuable summary of the findings of the Area Gas Supply Sub-Committee was given by Dr. E. W. Smith. The opinion was expressed by Mr. Clegg, of Burnley, that in his experience the class of coke produced in coke ovens is not comparable with ordinary gas-works coke for domestic purposes. In Burnley he has to meet intense competition from the local coke plants, and at prices which are 2s. per ton more than his own he finds that they are not successful in meeting more than 5 p.ct. of the requirements of the town. He maintained that one of the advantages in the production of gas in coke ovens is the fact that benzole is abstracted, and he criticized Mr. Stewart's figure of 21s. 6d. per ton for coal used in coke ovens, verticals, and horizontals—for the simple reason that he can utilize in his horizontal plant coals which cost 5s. per ton less than those used in verticals, in spite of which he is successful in obtaining 75 therms per ton. On the matter of coke quality, Mr. Copp said he had no doubt that the coke oven people were able to use a lower grade of coal, but that this must be reflected in the quality of the coke produced. Mr. Sensicle was by no means pleased to note the absence of any mention in the paper of intermittent verticals, which he likened to small coke ovens on end. He observed that new developments in the coking industry had resulted in a net heat consumption of not more than 500 B.Th.U. per pound of coal carbonized—a figure considerably lower than that given by the author. The last speaker in the discussion was Mr. Carr, of Stretford, who pertinently remarked that we are all inclined to say that if we can get coke oven gas at a price which is lower than the price of our own gas into the holder, it will pay us to buy it; but he issued the warning that the cost of our gas into the holder is not necessarily the cost of the additional gas that we might have to make over and above what we are already producing. He is sure that some contracts recently made for the purchase of coke oven gas might not have been entered into had the proposition been considered from the point of view not of average cost, but of what would be the cost of the additional gas where there was surplus plant available in the gas-works. He also referred to the figure

AT THE WAR MEMORIAL.

Left to right: Mr. J. H. Canning, Mr. H. E. Copp, the President (Mr. C. S. Shapley), Sir Francis Goodenough, Mr. J. R. W. Alexander, Mr. H. D. Madden, Mr. W. E. Price, and Mr. John Terrace.

given by the author for the heating efficiency of horizontals. "This," said Mr. Carr, "is a very unfair figure on to-day's practice. A figure of 1875 B.Th.U. per lb. of coal represents ridiculously bad working to-day. With waste-heat recovery and carbonizing washed smalls, I am achieving a figure of 820 B.Th.U. per lb. of coal."

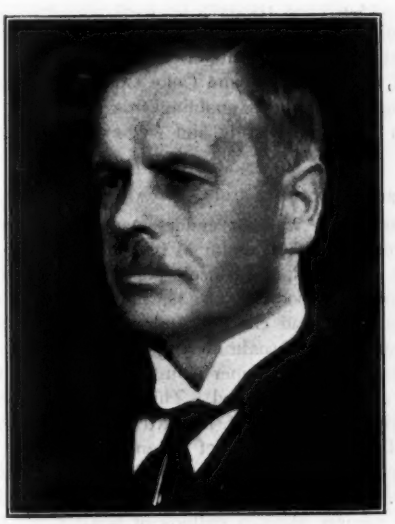
Waterless Gasholders.

Thursday morning's session was brought to a close in a thoroughly entertaining way. Mr. Prentice introduced his paper on "Experiences with the Waterless Gasholder" in a manner which pleased us and the entire audience, we think. Gas engineering is a really interesting subject, and can be dealt with in a really interesting manner. Every time, in brief, give us the imaginative, the human, touch. Mr. Prentice, we thank you for setting such a fine example; we thank you also for having the courage of your convictions, and being the pioneer of waterless gasholders in this country. No one could have been more fitted to speak on the subject.

In his paper, the author described the working of the Ipswich waterless holder—how it functioned through the perilous winter of 1928-29; how it reduced the cost of foundations, &c.; how it resulted in better service to the consumer. So manifold are the advantages of the waterless type of holder, said Mr. Prentice, "that were I requiring a holder to-day I should certainly choose a waterless, even if I had to pay a rather higher price for it."

Not All of One Mind.

Mr. Blundell, of Carlisle, was the first to cast shadows on the waterless holder. "I have a holder," he said, "in which the pressure of the top lift is 6 in.; and while the claim for constant pressure is not sustained, it must be admitted that the variation is negligible." He spoke of the extra supervision of a skilled nature which is necessary with the waterless holder; and he concluded by remarking that the very simple water-sealed holder should not be lightly abandoned in favour of the new idea until engineers have satisfied themselves that they are getting real advantages, and are not merely going in for the latest thing. Mr. Townsend, of Colchester, was careful to say that the subject was not one on which one could dogmatize. Of course, few subjects—engineering or otherwise—benefit greatly by the well-meaning application of dogma. However, he is pleased with Mr. Prentice, and is particularly delighted that he looks after his holder daily, and "logs-in" all details. Remember local circumstances, said Mr. Townsend, as he sat down. Mr. Valon Bennett, of Rochester, asked whether the waterless holder could be enlarged while working; and the author of the paper assured him that this could be done with ease. Mr. Tarratt, of Newcastle, justified his recent decision to erect a water-sealed holder, and surprised both the author and many present with



Mr. FRANK PRENTICE.

the assertion that "the point that has been made in regard to maintaining even pressure throughout the entire travel of the holder does not appeal to me." One of the most valuable contributions to the discussion was that of Mr. Carder, of Rio de Janeiro, who showed himself as witty as he was profound. Mr. Robinson, of Harrogate, spoke of wind pressure and expansion, on both of which points Mr. Prentice had ready reply.

Mr. Chaloner, of the Waterless Gasholder Company, appeared in the rôle of genial philosopher; and his remarks are well worth noting.

Thus ended the morning session.

Benzole Recovery.

The final technical contribution to the proceedings was a paper by Mr. W. H. Hoffert and Mr. G. Claxton on benzole recovery in gas-works, which was presented by Mr. Hoffert. Benzole is a highly satisfactory anti-knock motor spirit, and the paper shows that a substantial profit may reasonably be expected from its recovery on many works. The total cost of recovery and refining, including labour and all overhead charges, for a medium sized gas-works recovering benzole from horizontal retort gas is about 6d. per gallon of refined benzole. At to-day's selling price of 1s. 5d. per gallon for refined benzole, the net price per gallon is about 11d., which, with 5 to 10 p.ct. refining losses, is equivalent to a value of 6d.-7d. per therm in the gas. Some indication of whether it is profitable to recover benzole at a works of this character is afforded, therefore, by a consideration of whether it is profitable to provide an outlet for an additional 5 p.ct. of the therms sold, at a price of 6d. to 7d. per therm, without incurring additional distribution charges. The "new customer" taking these additional therms does not require a guaranteed supply, since the benzole recovery plant can be closed down if necessary when there is a sudden extra demand for gas. Actually many medium and large sized gas-works already quote prices to their largest consumers well below this figure, some favourably situated undertakings quoting figures as low as 4d. per therm, even for gas containing relatively little water gas and no coke oven gas. There is little doubt that these and other undertakings would be prepared to quote even lower figures for sales of the size and character indicated.

The recovery of benzole from gas produced in vertical retorts is less attractive than from that produced in horizontals; but, although benzole recovered from vertical retorts without steaming may contain about 10 p.ct. by volume of paraffins and 10 to 15 p.ct. by volume of unsaturateds, the difference in the value of therms as benzole and the price at which therms are sold to large consumers by many gas-works using verticals is still sufficiently wide to indicate that benzole recovery would be profitable on these works. Even if the retorts are steamed and give a benzole with 20 p.ct. of paraffins and 25 p.ct. refining loss, the net value of the benzole as therms in the gas apparently is still not less than 4d. per therm.

The authors discuss recovery by both oil-washing processes and adsorption by active charcoal. Regarding the latter, they observe that the improvements effected as a result of the recent research of the Gas Light and Coke Company appear to have gone a long way towards enabling this process to enter into competition with the existing and well-established oil-washing methods.

An Endorsement.

The discussion was an endorsement of the paper. The President remarked that, as far as his experience on one works in Leeds is concerned, the benzole plant in 1929 consumed the equivalent of 66,760,000 c.ft. of gas, and the price realized after deducting all overhead charges and working expenses of the benzole plant was approximately 3s. 3d. per 1000 c.ft. The charge to an outside consumer using less than one-third of this amount is 2s. 3d. a thousand. This, suggested Mr. Shapley, ought to give some idea of the attractiveness of benzole recovery. Mr. Firth, the Chief Chemist at Leeds, who has studied the problem very closely, backed-up what the authors had to say. He was followed by Mr. Tarratt, of Newcastle. There they recover about 3 gallons of benzole per ton of coal carbonized; and he supported the authors' statement that the cost is well under 6d. Up to the present, Mr. Tarratt has no disadvantage whatever as the result of taking benzole out of the gas. "I do not think you need have the slightest hesitation in adopting benzole recovery," he said. Mr. Copp expressed the doubt whether benzole recovery is actually profitable in the case of vertical retort gas; while Mr. Webb, of Leeds, assured those present that benzole recovery, far from being a source of trouble to a gas-works manager, has the opposite effect. "There is no trouble at all," he said, "in connection with the working of the benzole plant. One of its advantages is that by its use a gas-works with horizontal retorts becomes a very elastic unit; in enables one to carbonize coals of very different qualities. . . . Naphthalene troubles, instead of being accentuated, are practically things of the past." Mr. Hollings corrected some of the figures which the authors had used in relation to the active carbon process; and he remarked that, while he is in general agreement with what the authors say regarding the economics of benzole recovery, it does not appear to him that it can be claimed that the financial burden of carrying gas-making idle plant is reduced by the installation of benzole recovery plant if it is also claimed that the cost into holder of the therms represented by benzole removal is to be exclusive of capital charges. Mr. Sensicle says that he finds it difficult to conceive of circumstances in which there can be any serious doubt that benzole recovery does pay in gas-works.

The Concluding Stages.

The President announced that the Research Reports will be presented at the Autumnal Meeting of the Institution on Nov. 25 and 26, at the Incorporated Accountants' Hall, London; and, on the proposition of the President-Elect, it was decided that the next Annual Meeting should take place in London on June 2, 3, and 4, 1931.

International Illumination Congress, 1931.

Capt. W. J. Liberty then took the opportunity of reminding those present of the International Illumination Congress which is to be held in this country next year. About fourteen nations, he said, will be participating in the congress. The delegates will meet in Glasgow, Edinburgh, Newcastle-on-Tyne, Sheffield, and Birmingham—spending one day in each of those places—and they will then meet in conference in Cambridge for a period of two weeks. Sir Francis Goodenough is Treasurer to the Congress, and the Institution is well represented on all the Committees dealing with the details.

Presentation of Presidential Certificate.

Mr. Copp: My first duty in a Presidential capacity is one of the most pleasant duties that will ever devolve upon me. On your behalf I have to ask our retiring President, Mr. Shapley, to accept the certificate of his Presidency of the Institution of Gas Engineers. Our retiring President is known to you all particularly for his geniality, his fearlessness, his straightforwardness, and also for his organizing powers; and all who have attended this conference must pay tribute to his very great organizing ability. He combines in his personality many excellent qualities besides those to which I have referred. He possesses the shrewdness which we attribute generally to Yorkshiremen—though I do not know what part of the country he came from originally. Again, he has great generosity, and he is always very tolerant of his colleagues' weaknesses.

The Presidential Certificate was presented to Mr. Shapley, amid applause.

Vote of Thanks to Mr. Shapley.

Mr. Ralph Gibson: I ask you to accord our very best thanks to our retiring President for his work on our behalf during the past year. Mr. Shapley has presided over the numerous meetings of our committees with conspicuous ability and success. Reference has already been made by Mr. Copp to many of his excellent qualities, but we on the Council appreciate, perhaps more than the ordinary members have an opportunity of doing, how valuable his services have been during a year of considerable difficulty. He has not spared himself in his devotion to the work; he has attended the numerous meetings of District Associations, and he has represented the Institution worthily at the meetings of other bodies. In regard to this annual meeting in Leeds, I am sure we are all delighted with everything that has been done here.

The proposition was seconded by Mr. Botley and the vote was carried with acclamation.

Mr. Shapley, in reply, expressed his appreciation of the manner in which he had been supported by the Lord Mayor and the City Council, by the Gas Committee, through its Chairman and Deputy-Chairman, and by his staff. He also thanked the Council of the Institution, Mr. Price (the Hon.

THE NEW PRESIDENT.

HAROLD E. COPP,

Engineer and Manager of the Hull Undertaking of the British Gas Light Company, Limited.

Mr. Copp is the youngest son of the late Mr. W. L. Copp, who was closely associated for many years with the gas industry in the West of England, and was inventor of the first anti-dip valve for attachment to hydraulic mains, used extensively by London Gas Companies about fifty years ago. Educated at Wycliffe College, Mr. Harold Copp began his career in the gas industry in 1892 as a pupil under the late Mr. Fletcher W. Stevenson, at that time Engineer to the Sheffield Gas Company. Later, he acted as clerk of works on the construction of the Grimesthorpe station of the Sheffield Gas Company, and acquired considerable experience on large civil engineering works. He studied at Sheffield University College, gaining certificates in technical subjects, including civil engineering, metallurgy, and chemistry. In 1896, Mr. Copp left Sheffield to become engineering assistant to the Stockport Corporation Gas and Electricity Department, and was subsequently appointed Assistant Gas and Electrical Engineer. In 1902 he went to West Bromwich to take charge of the Corporation Gas Undertaking, where he designed and carried out many improvements and additions to the works. He also conducted a series of experiments on the enrichment of blue water gas by Peebles oil gas plant, worked in conjunction with the Dellwik-Fleischer blue water gas plant. In 1908 he was elected President of the Midland Association of Gas Managers. Mr. Copp's connection with the British Gas Light Company began in 1914, when he was appointed Engineer and Manager of the Potteries station, where he was responsible for the erection of one of the first plants for the production of benzole and toluol. The design of this plant was afterwards adopted by many other gas-works. On the retirement of Mr. John Young in 1919, Mr. Copp was transferred to the Hull Station, and since that time the works and plant have been largely extended and improved under his administration. The nominal capacity of the coal gas plant at the present time is 10,392,000 c ft per day, and that of the water gas plant, 4,300,000 c ft per day.

Secretary), and the Secretary (Mr. Alexander). "Any measure of success I have achieved," he concluded, "has been due to the help I have received not only from all those I have mentioned, but also from my wife."

Congratulations to Mr. Copp.

Following his election to the Presidency of the Institution, Mr. Copp received the following telegram from Hull:

> The officials, foremen, and men of the Hull Station of British Gas Light Company, Ltd., desire me to convey to Mrs. Copp and yourself heartiest congratulations on your accession to the Presidency of Chartered Institution of Gas Engineers, and to offer their wishes for a very successful year, assuring you of the loyal support and co-operation of every man. (Sgd.) Weston."

Presentation to Mr. Shapley.

It was announced by Mr. Shapley that the officials and workmen of the Gas Department at Leeds had presented him with a wireless gramophone set and an album containing over a thousand signatures of subscribers—a presentation which gave him the greatest gratification and pleasure.

Votes of Thanks.

The meeting was terminated by a series of votes of thanks. Mr. Shapley thanked the Lord Mayor and Lady Mayoress of Leeds, and both Councillor Morrison and Mrs. Morrison replied. A vote to the Leeds Corporation Gas Committee was proposed by Mr. Copp, seconded by Mr. J. H. Canning, and replied to by Councillor E. J. Clarke, Chairman of the Gas Committee. Mr. Tarratt and Alderman Fred West proposed and seconded a vote of thanks to the University of Leeds, to which Prof. Cobb responded. The Yorkshire Commercial Section of the Manchester District Institution of Gas Engineers and the Ladies' Reception Committee were thanked on the proposition of Mr. Shapley; and Mr. E. H. Hudson and Mr. J. E. Lister Cooper replied. Mr. W. S. Morland and Mr. Lister Cooper proposed and seconded a vote of thanks to Earl Fitzwilliam. The Staff of the Leeds Corporation and the Gas Department were thanked on the proposition of Mr. W. W. Townsend, seconded by Mr. Belton. Mr. R. N. Webb, Manager of the Meadow Lane Gas-Works, replied to this vote. Mr. Botley proposed, and Mr. F. Blackburn seconded, a vote to the Officers, Auditors, Council, and Committees of the Institution, to which Mr. Copp and Mr. Price replied. Prof. Cobb responded to a vote to the Authors of Papers and Reports, and to the Scrutineers, which was proposed by Mr. C. H. Carder, seconded by Mr. Wilson, and supported by Mr. Shapley. The final vote—to the Secretary and Staff of the Institution—was put by Mr. Copp, seconded by Mr. Ralph

Gibson, supported by Mr. Price and Mr. Shapley, and responded to by Mr. Alexander.

At the conclusion of the meeting the members joined in the singing of the National Anthem. Mr. Shapley called for three cheers for the Organist, Mr. F. H. Robinson, who had given recitals from time to time during the period of the conference. The cheers were given lustily, and were responded to, amid much laughter, by the sounding of one shrill note.

The Visits.

Both the official visits on the Wednesday afternoon were largely attended, and each was of high interest, as demonstrating the best practice in its particular field. The new Distribution and Street Lighting Workshops of the Leeds Gas Department, which were opened only a few months ago, and have already been described in our pages, are an example of modern practice in which all found something to admire. No less was the interest manifested in the Department of Coal Gas and Fuel Industries (likewise described by us a fortnight ago) and the Department of Mining at the University of Leeds, where science and industry are so happily blended. Professor Cobb and his staff displayed justifiable pride in their Department, and it was gratifying to find that quite a large number of members of the Institution were taking advantage of the opportunity to make personal acquaintance with a place which all know so well by repute. In the Mining Building the visitors found tea awaiting them.

Thanks are due to all who contributed to the success of these visits, as well as to the Leeds Gas Department, to the Harrogate Gas Company, to the York Gas Company, to Messrs. Clayton, Son, & Co., Ltd., and to Messrs. Wilsons & Mathiesons, Ltd., who threw open their works during the week for official visits by those attending the conference.

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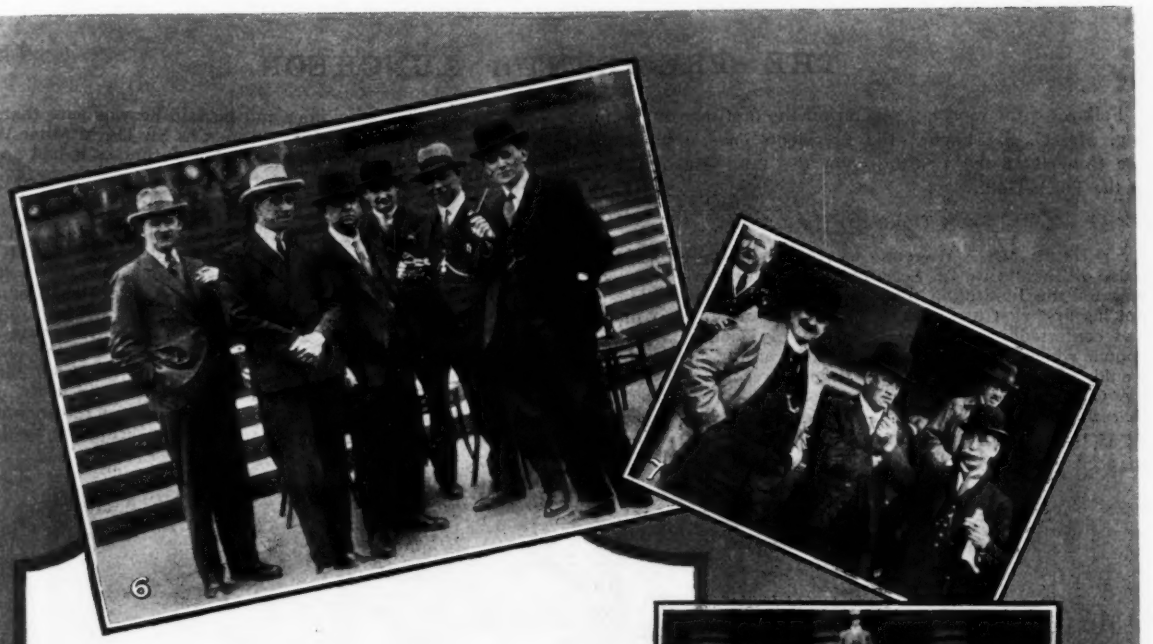


6.—E. G. CLARK (Birmingham), W. H. HAMMOND (Eastbourne), W. W. HAMMOND (Bognor), R. W. HAMMOND (Eastbourne), and W. A. BARNETT (New Barnet).

7.—C. A. GOODALL (Leeds), F. G. SHAW (Buxton), L. W. NUTTALL (Pembroke Dock), and L. SHAW (Rothwell).

8.—E. G. CLARK (Birmingham), R. W. HAMMOND (Eastbourne), J. S. NAYLOR (Rotherham), W. W. WOODWARD (Salford).

9.—I. G. JENKINS (Abertillery), Mrs. T. WILKINSON (Abercarn), THOS. WILKINSON (Abercarn), and W. COLLIN (Bridgend, S. Wales).

10.—C. S. WILSON (Barnsley), G. HAMILTON (Barrhead), T. WOODCOCK (Stroud), and A. BROMLEY (Keighley).

SOCIAL EVENTS.

THE PRESIDENT'S LUNCHEON.

Following the morning session on the first day of the meeting, Mr. C. S. Shapley, the President, gave a luncheon to the Council of the Institution in the Lord Mayor's Rooms at the Town Hall.

FROM DOMESDAY TILL NOW.

Sir DAVID MILNE-WATSON, LL.D., D.L., in proposing the toast of the "City of Leeds," said what a great honour it was for the Institution to be present in that city. This was not his first visit to Leeds, for a few years ago the University had conferred upon him the Degree of Doctor of Laws—an honour which, he could assure them, he highly appreciated. It would, of course, take a long time to recount the merits of the City of Leeds. In the Domesday Book, it was stated that the township consisted of 1000 acres which were tilled by 35 farmers. In 1379, there were 50 families; and shortly after this a band of Flemish came in and commenced the wool trade. When the Second Charter was granted to the city by Charles I., he appointed Thomas Danby, together with twelve discreet and honest burgesses; and there was a careful provision that the alderman and his assistants should serve during their lives except in the event of evil behaviour, or evil carriage, or other "reasonable" cause. Well, he would not delve further into the history of Leeds, but he would say that they all admired this great city. They also admired the gas undertaking, which was commenced in Leeds as early as 1818—only a few years after the manufacture and supply of gas had been inaugurated as a means of illuminating cities. It was, in fact, only six years later than the Chartered Gas Company—the forerunner of the Gas Light and Coke Company—had started operating. "I am," said Sir David, "filled with admiration for the enterprise and the civic spirit which pervades the City of Leeds."

ENVY AND APPRECIATION.

Sir ALBERT BALL, who supported Sir David Milne-Watson in his proposal, said that Nottingham envied and at the same time appreciated the University of Leeds. In Nottingham they were trying to copy the example which the University of Leeds had set; and this might be rendered possible, thanks to the generosity of Lord Trent. He wished prosperity to the Leeds Gas Undertaking; and he said he was sure that, if the gas industry was led by such men as Sir David Milne-Watson, it would continue to prosper in the future as it had prospered in the past.

STEEL COFFINS WILL MAKE THE HUNDRED.

The LORD MAYOR (Councillor N. G. Morrison, J.P.), responding to the toast, first of all referred to Sir David Milne-Watson's remarks on the number of councillors at the time of the granting of the second Charter. The present Council, he said, consisted of 68 members, and on Nov. 1 next this number would be increased to 104. In Leeds there were 99 different trades and industries. Not long ago he set out to discover a trade which was exclusive to the United States of America, and he found that such a trade existed in the making of steel coffins. If, then, Leeds commenced the manufacture of steel coffins, the missing trade would bring the total to the round hundred. If there was one outstanding individual in the City of Leeds, continued the Lord Mayor, it was Lord Brotherton, who had done so much for both the city and the University. He (the speaker) expressed his gratitude for the kind and generous terms in which the toast had been proposed. They had expended three millions of capital on the gas undertaking of the city, and the Manager, their President, was always ready to bring the interests of gas before the people of Leeds. In conclusion, he hoped the conference in Leeds would give them something to remember in the days to come, and he wished the gas industry and all present much prosperity.

THE LORD MAYOR OF LEEDS (COUNCILLOR N. G. MORRISON, J.P.), THE LADY MAYORESS, MR. AND MRS. SHAPLEY, AND THE PRESIDENT-ELECT AND MRS. H. E. COPP.

LONG ASSOCIATION WITH THE GAS INDUSTRY.

Lord BROTHERTON OF WAKEFIELD, LL.D., D.L., proposing the toast of the Institution of Gas Engineers, mentioned that he had been associated with the gas industry for nearly half-a-century. One of his earliest recollections was of Henry Woodall, who was at the time Engineer to the Leeds Gas Department, and who was still with them. Only the day before he had had a letter from him explaining his inability to be present at the meeting because he had taken a cold. In regard to the Institution of Gas Engineers, they in Leeds could claim particular association, for there had been endowed at the Leeds University a Chair in Gas Engineering which was

MRS. SHAPLEY AND SOME OF HER PARTY AT TEMPLE NEWSAM.

of value not only to Leeds, but also to the whole gas industry. If he could give them a word of advice, he would suggest that the rising gas engineers should come to the University of Leeds for their training, and also that gas engineers should come to Leeds firms for good gas engineering plant. He was proud that the Institution were paying the city a visit, and he was proud of their President, who did well to supply gas in his area at such a low price.

GAS FOR STREET LIGHTING.

Councillor C. F. TETLEY, M.A., LL.D. (Chairman of the Leeds Gas Committee, 1908-10), said it was an honour to follow Lord Brotherton, who had done as much as anyone to increase the profits of the gas industry. Gas had been a public necessity since the beginning of the last century, and he wished to thank the gentlemen present for having maintained the virility of their industry. As far as street lighting was concerned, nothing could touch gas in England. In Berlin, in Dresden, and in many other great cities in Europe, the gas lighting was the best that could be found. As for competition, this was an admirable thing provided they employed the right methods in meeting it. Practice must go with science, and science must go with practice; and the University of Leeds provided a splendid example of how this could be accomplished.

The PRESIDENT thanked Lord Brotherton and Councillor Tetley, with both of whom, he observed, he had been associated at Leeds. As for the members of the Institution, they were proud of their membership, and they were proud of an industry which had done, and continued to do, untold good. If everyone used gas liberally, the price would inevitably be reduced; and with this reduction in price and increased use of gas, the air of our towns would become purer. As it was at present, they were hampered by antiquated legislation—most unjust bearing in mind their competition from electricity. This unfair legislation, said Mr. Shapley, must be altered. "I am very glad," he concluded, "to see so many friends present; and it is very fitting that I should finish my year of office surrounded by members of my own Committee and by Councillors of my own city."

Sir ARTHUR M. DUCKHAM, G.B.E., K.C.B., in proposing the toast of the "Visitors," said that the industry did not obtain as much publicity as it ought to get. They should broadcast their ideas of service and the continuity of supply, which was a fetish, he might say, of all interested in gas. There were failures in electricity, and nothing was thought of them; but a failure of gas would be an unheard of thing. The President had spoken of the matter of smoke abatement. In this regard he (the speaker) thought that municipalities did not take enough trouble about the matter. There was no excuse for this smoke, and the work of the gas industry would not be finished until there was no smoke; anyone who poured smoke into the atmosphere was a bad citizen. Sir Arthur concluded by expressing his delight at the presence of the other guests. "The kindness of brother engineers who came from abroad," he remarked, "is a fine thing for the industry, and this spirit of co-operation ought to be encouraged.

Councillor E. J. CLARKE (Chairman of the Leeds Gas Committee) said that Leeds was honoured by their presence at the conference, which he hoped would be of great benefit. It was an honour to Leeds that the Institution had chosen Mr. Shapley as their President, whom they in Leeds had always considered a good Engineer, Manager, and Administrator generally. He (Mr. Clarke) said he would like to take the opportunity of congratulating Sir Francis Goodenough on the honour which he had received that day. His name was a household one in the industry, and his ability had been quite properly acknowledged by his confrères for many years past, and it was a delight to realize that it had now been recognized by the King. Also, he would like to congratulate Dr. E. W. Smith on having become a Companion of the Most Excellent Order of the British Empire.

Dr. H. SCHUTTE (Bremen), who responded, said he had always received great hospitality in England from his colleagues in the gas industry; and he expressed the wish that this happy association would be maintained for a long time.

THE RECEPTION.

The business of the opening day having been transacted to the satisfaction of all, the evening was given over to pleasure, and the Victoria Hall presented a brilliant scene, when the Lord Mayor and Lady Mayoress (Mr. and Mrs. N. G. Morrison), accompanied by the President and Mrs. Shapley, and Mr. and Mrs. H. E. Copp, held a reception. In addition to members of the Institution and their ladies, there were present many well-known Leeds citizens, the gathering being fully representative of civic life in the city. During the reception, Mr. Frank H. Robinson, Assoc.M.Inst.C.E., gave a greatly appreciated organ recital. There was dancing to the strains of "Charlie Steel and his music;" the dance programme being happily varied with a few old-time dances. During the evening Mr. J. Woods Smith, who officiated as Master of Ceremonies, entertained the guests with a short concert programme, which included contributions by Stainless Stephen, Daniell and Forrest, banjo duets, and items by Mr. Woods Smith himself.

Altogether a fitting conclusion to a successful day.

SOME SNAPSHOTS AT TEMPLE NEWSAM.

UNIVERSITY LUNCHEON TO THE COUNCIL.

The Council of the Institution were, on Wednesday, the guests of the Council of the University of Leeds at luncheon in the Staff House. The guests were warmly welcomed, on behalf of the University, by the Vice-Chancellor (Dr. J. B. Baillie), who pointed out that the visit to Leeds happened to have several peculiar and interesting features. It was, he understood, the first occasion on which the Institution had visited Leeds, or had had the pleasure and honour of being presided over by a Leeds man. Also it was the first annual meeting since the granting of the Royal Charter. The number of acceptances constituted a record; and one of the most distinguished members, Mr. Goodenough, had appeared in the Birthday Honours. The University congratulated the Institution upon this honour. Another very distinguished member, Dr. E. W. Smith, had been awarded the C.B.E. He expressed the University's appreciation of the handsome way in which the Institution and the gas industry had made themselves responsible for the first Chair of such a character to be instituted in any University in any part of the world. It was through the generosity of the gas industry, combined with the Institution, that the Livesey Chair was inaugurated. The University highly valued the work done. They realized the important part that science must always play in industry.

On the proposition of Mr. H. E. Copp, a cordial vote of thanks was accorded the University for the kind hospitality extended to the visitors. The association between the University and the gas industry was, he said, a very close one. The industry regarded Prof. Cobb as a wise counsellor, and they never looked to him in vain. What was needed to-day was that the world should be told that the gas industry was of great and growing importance.

The Pro-Chancellor (Col. H. Tetley) returned thanks for the vote.

A SOUVENIR OF HARROGATE AND WHARFEDALE.

THE LADIES.

The programme so carefully thought out for the enjoyment of the ladies, and which was foreshadowed by word and picture in our issue for May 28, was carried through with the smoothness that characterized the whole meeting.

They met together first at a reception given by Mrs. Shapley on the Tuesday afternoon at the Queen's Hotel, Leeds, where afternoon tea and excellent music were provided. Mrs. Shapley was supported by the President. On the following afternoon was the Temple Newsam visit; the historic mansion and the grounds, rich with rhododendrons and bluebells, being open for the visitors. Wentworth Woodhouse, on Thursday, was reached by about an hour's run in a fleet of private cars kindly lent by delegates to the conference. There, as the guests of Earl Fitzwilliam, they were shown over the mansion and chapel, and then sat down to tea in the grounds. The numbers who took part in these visits were eloquent testimony of appreciation of the arrangements.

A MOTOR TOUR IN WHARFEDALE.

By Friday morning there had been no falling off in the popularity and enthusiasm which had characterized the proceedings of the previous three days, and the assembly in Victoria Square for the start of the motor tour in Wharfedale must have been a source of gratification to Mr. Charles Wood, O.B.E. (by whom it has been arranged, and under whose direction it was carried out), and to all who were good enough to assist in the transport arrangements. In regard to the things which were under control, organization had left nothing to chance, and the one uncontrollable factor favoured the party, for the sun, which shone brilliantly at the start, did not flatter to deceive. The excellent photographs and brief details of the tour which we had, with the ever-ready help of Mr. Wood, been able to reproduce in the "JOURNAL" for May 28, had prepared strangers for some of the day's delights, but neither pen nor camera could do full justice to this, the finest of the Yorkshire dales. Probably but a small part of the route was level, but both drivers and cars (of which the transport solely consisted) proved equal to the test, and the

long procession that followed Mr. Wood had little difficulty in keeping to the straight path, so elaborate were the indications provided—extending even to patches of blue powder on the road where alternative ways presented themselves, and to occasional printed instructions by the wayside. Dotted about, at cross-roads, &c., along the route were police officers and motor scouts, who deserved thanks for their assistance.

How many cars there were in the procession, we will not attempt to say, but on arrival at the Majestic Hotel, Harrogate, over three hundred ladies, members, and friends sat down to a luncheon which was quite in keeping with so enjoyable a day. It was during this pleasant interlude that occasion was taken to express certain sentiments which were heartily applauded—Mr. J. H. Canning voicing the thanks of all present to those who had worked so hard and done so much to give them such a perfect day. He mentioned particularly the President and Mrs. Shapley and their old and esteemed friend Mr. Charles Wood. In the course of his remarks, Mr. Canning read the following letter addressed to the President by Sir Arthur Duckham:

Before leaving may I congratulate you on a most successful week? The organization has been splendid throughout. We have learnt much, have thoroughly enjoyed ourselves, and the dignity, vitality, and usefulness of the Institution have been enhanced under your Presidency.

Would you please give our warm regards to Mrs. Shapley, who, during a most trying week, has endeared herself to everybody.

May your successes ever continue.

This letter, it was felt, summed up most admirably the general feeling. The President, in response, thanked his Chairman and wife, and all his other friends for their great kindness to him. It had, he said, been a delightful week, and whatever effort was put into it had been made well worth while.

Before lunch Otley (where it was market day) had been passed through, and excellent views of Lower Wharfedale and of the Washburn Valley had been seen, while during the afternoon the beautiful pictures included Bolton Abbey, Darden Towers, the village of Burnsall, and Kilnsey Crag, all of which were illustrated in the "JOURNAL" a fortnight ago.

THE GOLF ON JUNE 2.

The fact that cards could be taken out up to 6 o'clock in the evening was largely responsible for there being as many as some 60 entrants for a medal round to be played for a handsome cup presented by Mr. C. S. Shapley and a pair of solid silver tankards given by the S.B.G.I. The course selected was Adel, where the "Evening News" 1000-Guinea professional tournament had just been completed. Thus it goes without saying that the course was in excellent condition; and all greatly appreciated the arrangements made for their comfort. For this, the stewardship was in the hands of the President and the following members of the Yorkshire Commercial Section of the Manchester Institution: Mr. J. Lister Cooper (Yeadon), Mr. James Bridge (Elland), Mr. A. C. Taylor (Royston), and Mr. A. L. Jennings (Cleckheaton).

The trophies were graciously presented by Mrs. Shapley in the course of the entertainment at the Tuesday night's reception.

The leading returns were:

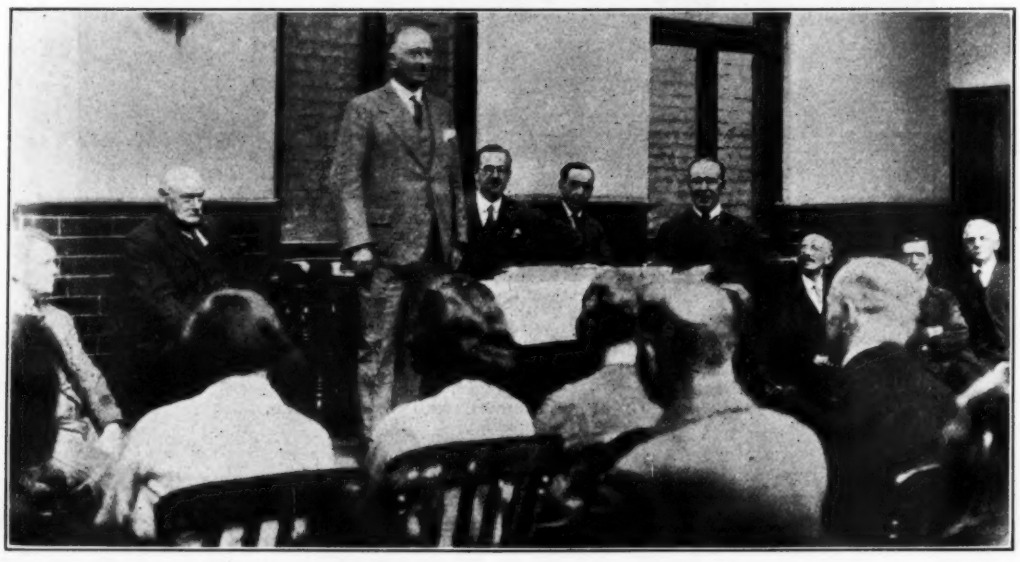
FOR THE PRESIDENT'S BOWL.

C. E. Holt	81 – 6 = 75
W. Clark Jackson	81 – 4 = 77
J. W. Whimster	100 – 23 = 77
G. Keillor	84 – 6 = 78
R. S. Tobey	87 – 9 = 78
H. W. Kaye	87 – 9 = 78
H. A. Aitken	89 – 10 = 79
E. H. Hudson	97 – 18 = 79
H. Curtis	96 – 16 = 80
H. C. Smith	95 – 14 = 81

FOR THE "S.B.G.I." TANKARDS.

K. W. Richmond	80 – 6 = 74
E. J. Davison	93 – 17 = 76
C. S. Shapley	97 – 19 = 78
H. M. Thornton	89 – 10 = 79
R. Miles	94 – 15 = 79
R. P. Chester	81 – 0 = 81
G. W. Allott	93 – 12 = 81

THE NEW PRESIDENT RETURNS TO HULL.



THE NEW PRESIDENT, MR. H. E. COPP, WELCOMED AT HULL.

A pleasing ceremony took place at the works of the British Gas Light Company, Bankside, on Friday afternoon last, when the officials and workmen assembled to welcome Mr. Harold E. Copp, M.Inst.C.E., M.Inst.Gas E., Engineer and Manager, after his election as President of the Chartered Institution of Gas Engineers.

Mr. F. C. Robinson said that, on behalf of all serving under Mr. Copp, he desired to express their very great appreciation of the honour which Mr. Copp had received and to wish both Mr. and Mrs. Copp a very happy and successful year.

Mr. R. A. Weston, referring to the honour conferred upon Mr. Copp, stated that he felt sure all would agree that the Institution could not have made a wiser choice, and assured Mr. Copp of the loyal support of all concerned during his year of office.

Mr. E. A. Atkinson and Mr. J. Hart also associated themselves with these sentiments.

Mr. George Smith, having the longest service with the Company in Hull, then presented to Mr. Copp a silver entrée dish suitably engraved, as a small token of their congratulations and good wishes.

In replying, Mr. Copp stated that during the past week there were times when he had felt deeply embarrassed, but never so much as he did at that moment. He said that the gift which had just been presented to him would be cherished by both his wife and himself as long as they had breath. In referring to the messages of congratulation which he had received, Mr. Copp said that none had made him feel prouder than the one which he received from the officials, foremen, and men at the Hull Station. He was also most gratified in the knowledge that the presentation was contributed to by every official and employee of the Company at the Hull Station.

The proceedings concluded with hearty cheers for Mr. and Mrs. Copp.

Presidential Address

By CHARLES STUART SHAPLEY, M.I.Mech.E., M.Inst.Gas E.,

Engineer and General Manager, Leeds Corporation Gas Department.

In addressing you on the occasion of this, our Sixty-Seventh Annual General Meeting, I should like first of all to express my thanks to all Members of the Institution for their continued loyalty since their unanimous election of me as President last year. Further, my gratitude is due to the Council and Officers of the Institution, the Readers of Papers, the Members of the West Riding Commercial Section Committee of the Manchester District Institution of Gas Engineers, the Staff and Employees of the Leeds Gas Committee, and the Gas Press, from all of whom I have received magnificent support. Further, I would especially pay tribute to the City Council of Leeds and the Gas Committee, by whose generosity and co-operation it was made possible for me to accept office.

Royal Charter and the Presidency.

The year 1929-30 commenced with the granting of a Royal Charter to the Institution, which was a fitting tribute to its 67 years' work for the gas engineer's profession and the Gas Industry. Simultaneously with the grant of Charter the Institution adopted somewhat more democratic methods. At the first Council meeting I moved, and the Council unanimously adopted a resolution, the object of which was to enable the office of President to be held by any member of the Institution, irrespective of his financial position, or whether his Company or Municipality, although willing to allow the amount of time and freedom of action necessary for the adequate discharge of the Presidency, might be unable to accept the financial responsibility which the office incurs.

Armorial Bearings.

The issue of a Membership Certificate to all Corporate and Non-Corporate Members, other than Students, is being proceeded with. The certificate has been designed by the kindness of Mr. F. D. Marshall, M.Inst.Gas E., who has helped us so admirably in such matters. It embodies the Armorial Bearings recently granted to the Institution by the College of Arms. We are indebted to Somerset Herald and the Secretary for the design of the Arms, which admirably represents, in correct heraldic language, the attributes of the Institution and the Industry, whilst the motto, "By diligent investigation we serve," is both unusual and appropriate.

Secretaryship.

Owing to the resignation of Mr. J. W. Campbell, M.Sc., it was necessary to appoint a successor, and after many meetings and interviews, Mr. J. R. Willis Alexander, M.A., LL.B., Barrister-at-Law, was selected from 602 applicants for the position of Secretary. He has shown considerable ability in schemes of reorganization and administration, and from my close personal contact with him, I am satisfied that the Council has made a wise choice.

Co operation.

I do not intend to emphasize the normal but nevertheless arduous responsibilities of the Institution as a body of professional men, since these matters are more appropriately dealt with in the Annual Report. The Council and its Committees meet regularly in furtherance of the interests of the Institution and its Members, and by maintaining liaison with kindred bodies contribute towards the common pool of knowledge and usefulness. Above all, we seek to secure adequate support of and co-operation with, organizations working in the interests of gas and particularly the National Gas Council and the British Commercial Gas Association, which so ably look after the Parliamentary, legal, and publicity interests of the Gas Industry.

British Industries Fair: Gas Conference.

The Joint Gas Conference which took place during the British Industries Fair in Birmingham in February, 1930, was a substantial success, and Mr. W. B. McLusky's paper on "Residual Products and Their Effect upon the Price of Coal," brought about a very interesting and informative discussion. The Council has resolved to support a further Joint Gas Conference and a Gas Industries Section at the Fair in 1931. It is hoped the arrangements will be such as to enable members to attend themselves and send their assistants, who should be encouraged to participate in the benefits which the exhibits and the conference make available.

Foreign Gas Conferences.

The policy of the Council has been that the Institution of Gas Engineers should be represented as widely as possible at all meetings directly connected with the Gas Industry, and in pursuance of this, several members, during the year, have visited Gas Conferences in Berlin, Rouen, and Stuttgart, whilst further delegates will shortly be leaving for the World Power Conference in Berlin, and the Gas Conferences in Halifax (Nova Scotia), Paris, Brussels, and Odense. In addition, I have visited every District Association throughout the country once or more during the year.

Medals and Scholarships.

The Revised Education Scheme has commenced to operate and a great deal of work, to make it thoroughly effective, is being done by the Gas Education Committee, under the able Chairmanship of Mr. F. W. Goodenough, C.B.E., M.Inst.Gas E. There is every reason to believe that the Scheme has been found generally satisfactory, and whilst some time must necessarily elapse before it becomes fully and effectively operative, it is felt that the Institution has a system of technical education and examination which is at least equal to any in the country. That interest is being focussed in the Education Scheme is evidenced by the kind offer of Mr. P. C. Holmes Hunt, M.Inst.Gas E., on behalf of himself and his brothers and sisters, to endow, in memory of their father, a Charles Hunt Memorial Medal in the Diploma in Gas Engineering and another in the Diploma in Gas Supply. Of beautiful design, the medals will be struck in gold and both will be awarded annually.

This reminds me of the very attractive Scholarship which has this year been generously endowed by Mr. P. F. Holmes and Mr. D. M. Henshaw in memory of the late Mr. William Cartwright Holmes, of Huddersfield. Worth £170 per annum, the William Cartwright Holmes Scholarship is intended to enable a student to take a course of study at the University of Leeds, in preparation for a responsible position in Gas Engineering. Scholarships such as this and the Corbet Woodall Scholarship discredit the contention that academic advancement and admittance to professional bodies is open only to those with means. Chartered Gas Engineers must, however, be recruited only from those men who possess education, training, ability, application, and a sincere belief in the future of the industry, and the Institution intends to pursue this objective to the utmost.

Institution and University Research.

I do not propose to address you as to the year's work of the Research Committees of the Institution or of its various activities at Leeds University, firstly, because the achievements of the past twelve months in research are reserved for the second Autumnal Meeting, and, secondly, because Professor Cobb will follow me by giving an historical outline of the extent and nature of the academic training and research work of the Institution.

The course adopted of holding an Autumnal Meeting of the Institution at which the Research Reports were presented and discussed, and of leaving the June Conference for the Annual General Meeting and the submission of papers, has proved such a success that similar arrangements have been made this year, and the next Autumnal

Meeting will be held in Incorporated Accountants' Hall, London, on Nov. 25 and 26, 1930. From the excellent verbatim report which the "GAS JOURNAL" published of last year's meetings, it will be observed that there was no dearth of speakers during any of the discussions.

OPPORTUNITIES FOR GAS ENGINEERS.

I should fail in my duty, however, if I did not draw attention to a problem which confronts the Gas Industry. I refer to the shortage of gas engineers with scientific training. The National Fuel and Power Committee view the situation with concern, and state in their report that if fuel utilization along scientific lines is to be secured, it is not only necessary to prosecute research, but also to ensure the application of its results, which can only be achieved by the employment on the executive side of industry of more men trained as fuel technologists.

In so far as the Gas Industry is concerned, the Institution has to some extent recognized the position by its special relationship with the University of Leeds, comprising research through Research Committees, and the training of gas engineers in the Department of Coal Gas and Fuel Industries, and the Livesey Professorship. The men thus trained are already permeating the Gas Industry and beginning to make their mark in it, but their numbers are insufficient.

In reply to employers offering positions of promise, Professor Cobb informs me that he has had to say, with almost monotonous regularity, that his men were all taken up and that in some cases men finishing their courses in the following year were already bespoken. In an age of overcrowded professions, therefore, it cannot be too widely known that the number of entrants for training as gas engineers and fuel technologists does not correspond with the increasing demand for qualified men. The promising boy leaving school should know that there is such a profession as that of gas engineer or fuel technologist, and that the prospects offered to the right type of man, properly trained, are excellent.

SCALE OF SALARIES.

One matter which has exercised the minds of members of Council is as to whether the Institution can take steps to secure the adequate payment of its members in their capacity as gas engineers, managers, and assistants of gas undertakings. The importance of the matter was recently illustrated by the action of a certain Corporation, in advertising for a gas engineer and manager, at a salary which was slightly above half the amount which it had independently ascertained it should offer. The Corporation persisted in making the appointment in spite of the representations of the Institution and other organizations and the resignation, by way of protest, of its Consulting Engineer, Mr. W. Doig Gibb, O.B.E., M.Inst.Gas E. If constructive and reasoned representations are in effect to be ignored, the Institution is left with two alternatives. One is to place an embargo upon the appointment by instructing (or suggesting to) its members that they should not apply, and the other course is to draw up a scale of salaries which, having the common consent of both employers and employees, would be observed as being in the nature of a national award. An embargo has the disadvantage that its general observance cannot be ensured, whilst the legal position is not without its difficulties. The negotiation of a scale of salaries would not be an easy matter, having in mind the diverse conditions which exist in different works and the fact that there are company owned as well as municipally owned undertakings. Assuming, however, that a scale is agreed upon and can be effectively enforced in all cases, it still has to be remembered that such a scale suffers by reason of the fact that what is intended to be minimum remuneration would, more often than not, be regarded as a maximum as well. However, the situation is being carefully watched and considered by the Institution, and the Council will not hesitate to take such steps as it deems expedient to ensure that chartered gas engineers are paid in accordance with their heavy responsibilities and the standard of integrity, training, education, and experience rightly expected of them.

SMALLER UNDERTAKINGS.

It is difficult in a Presidential Address, to say something which will be of interest to everyone, but I am not unmindful that amongst my hearers there are many members who are from comparatively remote parts and who are in control of the smaller gas undertakings. Having at one time been in charge of a number of such works, I am in a position to appreciate many of the difficulties of these undertakings. I owe much of my experience to the necessity for being thoroughly conversant with the details inevitably associated with their control, and particularly in regard to keeping the plant efficient.

REMODELLING OLD PLANT.

In the past few years, great improvements have been effected in carbonization by the employment of new and the remodelling of old plant. In the Leeds Corporation Gas-Works at New Wortley, we have horizontal retorts charged by hydraulic machinery, installed in 1896, and inclined retorts erected in 1903. By the careful re-designing and re-building of this plant, the make per ton has increased since 1918 from 12,400 c.ft. to 14,600 c.ft., whilst the make per through retort has grown from 14,200 c.ft. to 19,000 c.ft. per 24 hours. In addition, we are carbonizing from 3 to 4 cwt. of coal more per through retort per 24 hours, and there is a yield of about 3 gallons of crude benzole per ton of coal, with a gas of 470 B.Th.U.

A further economic advantage is that many of the beds have worked 2200 days at an average combustion chamber temperature of 1385° C., and they are in sufficiently good condition to work for a further 200 to 300 days.

These results have been largely brought about by maintaining carefully a constant slight pressure in the retorts, and it is worth recording that at the New Wortley Works no retort house governors or seals in the hydraulic mains are employed, and stopped pipes are a thing of the past.

With the adoption of the hydraulic ram, however, considerable difficulty was experienced after scurfing in pushing out the charges, in the case of retorts which had worked over 1200 days.

To overcome this we recently designed and installed a spray, and since spraying the retorts immediately after scurfing we have not had the slightest difficulty in discharging them. Investigations have shown that, as a result of this spraying, a definite flux is formed on the inside walls of the retorts, and I feel sure that this prevents loss of gas through the retort walls.

The considerations to which I have referred have confirmed me in the belief that one should proceed very cautiously before deciding to scrap even the oldest plant.

LEEDS DISTRIBUTION WORKSHOPS.

Since we are to visit the distribution workshops of the Leeds Gas Department during the course of the present conference, a short account of this Department may be of interest.

The distribution department was first housed at the Meadow Lane Gas-Works, but as the result of a fire, new premises were found in another part of Leeds, the property being leased from the Tramways Department. The development of the tramways, however, rendered another move necessary, and the Gas Committee decided to erect a modern building on ground which was their own.

The ground was originally an insanitary area, comprizing cellar dwellings which had been filled in. When the land was cleared it was ascertained that at 8 ft. below the ground, satisfactory foundations could not be found. Instead of the normal type of continuous spread footings on concrete, which would have been too expensive, in view of the great depth of walling necessary, we adopted a concrete pier and beam system to carry the superstructure. Generally we sunk pits at 15 ft. centres over the line of all walls and stanchion bases. These pits, or caissons as they seemed to be, were each carried to the depth that gave us a safe bearing area for the superimposed loads. Our deepest excavations went to 20 ft. below the surface, and the average depth was 12 ft. over the hundreds of pits dug. The pits were filled in solid with concrete, and girders, in turn encased in concrete, were run from concrete pillar to pillar.

The present building is lofty and well lighted, heated, and ventilated. Of steel construction, it is built of brick with terra-cotta dressings on certain elevations. Pro-

vision has been made for the future addition of offices and showrooms fronting on to New York Road, an important public thoroughfare. The first floor of the projected building would be level with the street.

The plan of the distribution department was carefully arranged to eliminate unnecessary handling of goods and so as to ensure that a normal forward sequence of work could be maintained from reception to despatch.

On the new Regent Street, a wide road that has been driven through the worst type of Leeds slum, the receiving dock is situated, which is over 100 ft. long, and enables at least eight lorries to unload at one time. Its platform is level with the main shop floor line and has at one end an electrically driven slat conveyor over 100 yards long, 3 ft. wide, and moving at a speed of 40 ft. per minute. It travels from one end of the building to the other, and serves the various sections of the department en route.

The meter and lamp repair section is planned as a complete unit, and contains, *inter alia*, the meter test, the repair shop, and a lead recovery plant. It adjoins the Magistrates' meter testing station, which is housed in the building.

The cooker and gas fire repair section consists of a large shop equipped with the most modern appliances and machinery. The general store, through which the travelling conveyor passes and from which goods are issued over a long counter into the gas fitters' assembling room, leads to a large store containing new and repaired appliances. Next one reaches the loading dock, which is also 100 ft. long, and the department is completed by offices, "clocking-on" hall, and workmen's canteen, and the necessary lavatories, boiler house, and yard.

For the heating, hot water and steam supply throughout the building, two upright "Cochran" boilers have been installed. The heating is by steam on an improved principle, with complete thermostatic control to regulate temperatures. In summer the unit heaters can be used as fans for cooling the air, a valuable asset in a workshop.

Distribution

In matters of distribution we very much favour the high-capacity meter, especially with larger installations. The compact size of the meter case entails considerably less work in handling and fixing, and occupies a minimum of valuable space on the consumer's premises. In connection with larger services, such as hotels and factories, it has been found a good practice to install main control valves in the footpaths. These are advantageous in case of fire and overcome large wastage of gas at such times.

All our salesmen are qualified fitters, which ensures expert advice for the consumer as to his appliances and the installation of supply pipes and fittings of ample dimensions. Further, our gas inspectors are trained to deal with inquiries, since these men come into frequent personal contact with consumers. On maintenance work only first-class fitters are employed in order that they should be able to undertake the through overhaul of any appliance. This practice has been found more economical than having different men for the various appliances, and does not subject the consumer to numerous visits which are regarded as vexatious.

Industrial Appliances.

It has been shown by the Leeds Industrial Gas Department that the preparation of a complete list of the industrial appliances in use serves a very useful purpose. The information obtained shows in what processes town's gas is used, and indicates the ground for further extension. Whilst there are some solid fuel operations which may be regarded as beyond the reach of gas, there is a very large amount of work in which the special advantages of gas fuel considerably outweigh the difference in cost. Special attention was given to an engineering works in Leeds, where solid fuel was largely used, with the result that the gas consumption was increased in the following manner :—

	C.Ft.
1927	4,930,300
1928	8,034,900
1929	16,377,300

Large-Scale Cooking.

Where the trade of a district is not concerned with the treatment of metals, or with other big industrial processes, a considerable outlet for gas can be found in food production. The gas appliances available for hotels and institutions are many and varied, and it can safely be claimed that in large-scale kitchen equipment, gas is beyond compare. The baker, confectioner, and fish fryer are worthy of special mention. In these trades, we have in Leeds over 400 consumers cooking entirely by town's gas. The ordinary retail shopkeeper in these trades consumes 50,000 to 200,000 c.ft. of gas per quarter, whilst one large wholesale baker frequently reaches 2,000,000 c.ft. of gas per quarter.

In connection with the installation of industrial appliances, we have found it desirable ourselves to prepare the scheme, provide plans and working drawings, estimate the cost, and carry out the whole of the work. Service after sales is also most important. Industrial appliances are in use for long periods, and, therefore, the burners are periodically cleaned and adjusted free of charge, whilst systematic visits are made for the purpose of maintaining the appliances in good and workable condition. The result is that, although trade in general has been depressed for some considerable time, the gas consumed for industrial purposes in Leeds has increased by 10 per cent. per annum. It may truly be said that solid fuel is being displaced by town's gas.

Carbon Monoxide.

In pursuance of a promise made by his predecessor in office, the President of the Board of Trade appointed last June a Departmental Committee under the Chairmanship of the Rt. Hon. Sir Evelyn Cecil, G.B.E., to consider the increase during recent years in the number of deaths ascribed to coal gas poisoning and to recommend any measures which might be taken with a view to diminishing the number of such deaths.

Some members spent a great amount of time and energy in the preparation of evidence which they gave before the Committee. Everyone acquainted with the position found difficulty in appreciating the need for any such investigation, and the Committee's unanimous report, published last February, constitutes a striking testimony to the safety which attends the provision of a gas supply to about 40 millions of the population of these islands.

The Coal Bill.

So much has been said on the subject of the Coal Bill, the passing of which would appear to be inevitable, that I had best do no more than again remind the public that any inflation in the price of coal will necessarily be reflected in an increase in the price of gas, which means an addition to the burden of the cost of living.

In a speech at Sheffield early in May last, Mr. Stanley Baldwin said : "This is a Bill which interferes in a way unknown to British legislation with the conduct of a great industry, and what I would say of that is this, that when one great industry is interfered with in that way, there is no assurance that any other industry you like in the kingdom may not be the next object of the Government's attention."

If this be an accurate statement of the position, it is no exaggeration to say that the gas industry in opposing the passage of the Bill has been acting in the best interests of industry generally.

Antiquated Legislation.

Successive Governments, failing to appreciate the real nature of the problem which confronted them, have striven enthusiastically to extend the use of electricity, regardless of its suitability for any particular purpose, and ignoring completely the part which has been played—and can in future be played—by the Gas Supply Service of this country. We have so far striven in vain to secure that measure of Parliamentary time and attention which is urgently needed to adjust the statutory control of gas undertakings to the requirements of the times.

Electricity legislation has been framed in recent years,

and it enables electricity authorities to extend the use of electricity, regardless of its effectiveness in each particular direction. Gas undertakings, however, work under legislative restrictions which, even if appropriate 50 years ago, are quite unsuitable to-day and impede our efforts to improve the service which gas can offer and handicap the extension of its field of usefulness.

OBSOLETE SUPPLY CHARGES.

A case in point is the system of charging for gas, which is in effect imposed upon us by statute. Unlike electricity supply authorities, gas undertakers are unable to make any fixed charge, in the case of consumers who only require a supply of gas for occasional use. The effect, as you are well aware, is that industrial and domestic consumers, who appreciate the advantages which gas offers and make full use of it, are indirectly obliged to subsidize the casual consumer.

Statutory authority must be given us to frame our tariffs so as to relieve remunerative consumers, both industrial and domestic, of charges which should properly be borne by others. The ultimate effect would be to extend the use of gas still further, with the result that the load factor would be improved and lower rates would be ensured to the small consumer.

Members of the Institution who have not already done so, should take a census of their consumers to ascertain those who are remunerative and those who are not. I anticipate that the resultant figures would occasion some surprise, whilst an analysis for the whole industry would show the retarding effect of obsolete legislation upon the development of gas supply.

Benevolent Fund.

Report of the Committee.

The Committee of Management of the Benevolent Fund of the Institution of Gas Engineers has pleasure in submitting to the Contributors its Report for the year 1929-1930, together with the audited Accounts for the year ended 31st December, 1929, and a List of Subscribers and Donors to the Fund.

The number of those receiving assistance from the Fund is now 14. The total expended in Grants in 1929 was £540. Visitors, appointed by the Committee, call upon each recipient at intervals and report as to the circumstances of the person receiving assistance and whether the case is being satisfactorily dealt with.

The amount received in Subscriptions was £342 15s., and the Donations totalled £211 13s. 5d., but this latter amount cannot be regarded as a regular source of income. The number of subscribers to the Fund was 518, Membership of the Institution being 1405 at the 31st December, 1929.

The Committee earnestly hopes that a large number of those who have not hitherto assisted the Fund will become subscribers during the year 1930, in order that the needs of those upon whom misfortune has fallen may be adequately met. Subscriptions of five shillings and upwards will be gratefully received, and a Banker's Order is available for this purpose.

In generously sending a donation of £100, Mr. Frank Harding Jones (London) wrote as follows to the President of the Institution (Mr. John Terrace) during the Annual Meeting in June, 1929:—

> "Dear Mr. President,
>
> "I enclose you a cheque for £100 for the Benevolent Fund of the Institution of Gas Engineers and will send the same amount for the next four years—making £500 in all—to be spent as the Committee for the year decide.
>
> "I send it to commemorate the Charter, your Presidency, and the Education Scheme you have done so much for.
>
> "FRANK H. JONES."

The Committee of Management expresses its gratitude for this gift, and conveys its appreciation to the District Associations, which continue to give valuable support to the Fund, and to Mr. Richard T. Surtees (Newton-in-Makerfield), whose ninth consecutive donation of £10 10s. has been received.

The three Trustees are now:—

Dr. Charles Carpenter (London),
Sir David Milne-Watson (London), and
Mr. Henry Woodall (London),

the last named having been elected at the Annual Meeting in June, 1929, to succeed Mr. Charles Hunt, who had been a Trustee up to the time of his death.

At the forthcoming Annual Meeting, Mr. Charles F. Botley (Hastings) and Mr. W. Eames Caton (Oxford) retire from the Committee, having completed three years' continuous service. As their successors the Committee have nominated for election Mr. James E. Blundell (Carlisle) and Mr. Frank Harding Jones (London).

C. S. SHAPLEY,
Chairman.

J. R. WILLIS ALEXANDER,
Honorary Secretary.

28, Grosvenor Gardens,
London, S.W. 1,
9th April, 1930.

Meeting of the Fund Contributors.

A meeting of the contributors to the Fund was held in the Victoria Hall in the Town Hall, Leeds, on Thursday morning, June 5, the President in the Chair.

The HON. SECRETARY (Mr. J. R. W. Alexander) read the notice convening the meeting, and the minutes of the previous general meeting were confirmed and signed.

The PRESIDENT: I propose:—

> "That the Report of the Committee of Management for 1929-30, and the Accounts for 1929, which have been printed and circulated among the contributors, be taken as read."

The resolution was carried.

ELECTIONS TO COMMITTEE OF MANAGEMENT.

The PRESIDENT: I have to announce that the Scrutineers of the ballot for elections to the Committee of Management report that Mr. J. E. Blundell and Mr. Frank Harding Jones have been duly elected.

I take it that all the gentlemen present at this meeting are really interested in the Benevolent Fund. Mr. Valon Bennett made an excellent appeal on behalf of the Fund at yesterday's meeting, and I hope that you gentlemen will do all you can among the members of the Institution who are not contributors to ensure that every member subscribes at least 5s. a year, which, after all, is only just over 1d. per week.

I should like to announce that Mr. F. H. Jones has sent his second contribution of £100 to the Fund. [Applause.]

No further business was raised, and the meeting of the contributors was closed.

New Members of the Institution.

On the Wednesday morning, the following were elected to Membership, Associate Membership, and Associateship of the Institution:

MEMBERSHIP.

Carpenter, George Ellis, Secretary and Manager, Gas-Works, Budleigh Salterton.

Clapham, Thomas Alborn, Managing Director, Clapham Brothers, Ltd., Wellington Foundry, Keighley.

Clark, George, Managing Director, The Bryan Donkin Company, Ltd., Chesterfield.

Drake, Jonas Wilfrid, Managing Director, Drakes Ltd., Halifax.

Duckham, Sir Arthur McDougall, G.B.E., K.C.B., Chairman and Director, Woodall-Duckham Vertical Retort Company, 150, Victoria Street, London, S.W. 1.

Harding, William, Manager and Secretary, Gas-Works, Ripley, Derbyshire.

Hawthorn, Sidney Kenneth, Institution Diplomé in Gas Engineering, 1st Class, 1929, Carbonizing Superintendent, Windsor Street Works of the Birmingham Corporation Gas Department.

Henshaw, Daniel Mayon, Manager and Director, W. C. Holmes & Co., Ltd., Huddersfield.

Hodgson, Richard Bowness, Managing Director, The Whessoe Foundry and Engineering Company, Ltd., Darlington.

Law, James Kay, Engineer and Manager, Gas-Works, Marple, near Stockport.

Lymn, Arthur Henry, Managing Director, Gas Chambers and Coke Ovens, Ltd., Artillery House, Westminster, London, S.W. 1.

Melvin, Duncan Dewar, Works Manager, Gas-Works, Uddingston.

Milbourne, Robert John, Managing Director, C. & W. Walker, Ltd., Donnington.

Peebles, William Carmichael, Managing Director, Peebles & Co., Ltd.

Pickles, Harold, Engineer and Manager, Corporation Gas Department, Morley, Yorkshire.

Pickles, Leslie Sutcliffe, Institution Diplomé in Gas Engineering, 2nd Class, 1929, Production Engineer, Corporation Gas Department, Halifax.

Teasdale, Charles Ernest, Deputy Engineer and Manager, Corporation Gas Department, Salford.

Tomlinson, Tom Ashton, Chief Engineer, West's Gas Improvement Company, Ltd., Albion Ironworks, Manchester.

Walker, Thomas Bertie, Director, Gibbons (Dudley), Ltd., and Gibbons Brothers, Ltd., Dibdale Works, Dudley.

Waller, Bertram Braund, Managing Director, George Waller & Son, Ltd., Phœnix Ironworks, Stroud, Glos.

Webb, Rowland Newell, Manager, New Wortley Works of the Corporation Gas Department, Leeds.

West, Ernest, General Manager, West's Gas Improvement Company, Ltd., Albion Ironworks, Manchester.

West, Frederick Joseph, C.B.E., Chairman and Managing Director, West's Gas Improvement Company, Ltd., Albion Ironworks, Manchester.

Williams, Tom Herbert, Engineer and Manager, Gas-Works of the London, Midland, and Scottish Railway Company, Crewe.

ASSOCIATE MEMBERSHIP.

Bradshaw, Richard John, Assistant Engineer and Manager, Gas-Works, Macclesfield.

Braidwood, Geoffrey Lithgow, Assistant Engineer, Harrow Station of the Gas Light and Coke Company.

Chapman, Leslie Benjamin, B.Sc. Eng., Assistant Engineer and Manager, Gas-Works, Tipton.

Daniels, John Henry, Technical Assistant, Gas-Works, Wallasey.

Davidson, Alexander Nicol, Senior Draughtsman, Gas Light and Coke Company, London.

Dawkins, Bernard William, Assistant Engineer, Staines Station of the Gas Light and Coke Company.

Deas, Cleveland Alexander, Assistant Engineer, Gas-Works, Hertford.

Fife, Robert, Assistant Engineer and Manager, Gas-Works, Kilmarnock.

Green, Frederick, Assistant Engineer, Nine Elms Station of the Gas Light and Coke Company.

Jones, William Trevor, Manager, Gas-Works, Fleetwood.

Lowe, Frank, Technical Assistant, Gas-Works, Ramsgate.

McDonald, Alexander, Chief Assistant to Engineer and Manager, Gas Department, Motherwell and Wishaw.

Morton, Robert, Assistant Engineer and Manager, Gas-Works, St. Austell.

Nadin, John George, Works Manager, Hollinwood Works of the Corporation Gas Department, Oldham.

Nicholson, Leslie Frere, Engineer-in-Charge, Kowloon Works of Hong Kong and China Gas Company.

Parkinson, David Bernard, M.A., Assistant Engineer, Nine Elms Station of the Gas Light and Coke Company.

Ratcliffe, Frederick George, Assistant Engineer, Gas-Works, Cape Town, South Africa.

Scadding, William Wallace Henry, Assistant Engineer, Nine Elms Station of the Gas Light and Coke Company.

Shaw, Morris Turner, B.Sc. Eng., Technical Assistant, Corporation Gas-Works, Belfast.

Tatam, George William Gerald, Chief Assistant to Engineer, Gas-Works, Croydon.

Tran, Alexander, Assistant Engineer and Manager, Gas-Works, Helensburgh.

Walker, Rowland, Manager, Partington Works of the Corporation Gas Department, Manchester.

ASSOCIATESHIP.

Auty, Austin Blackburn, Assistant to Managing Director, Clapham Brothers, Ltd., Wellington Foundry, Keighley.

Banford, Francis Edward, Designer, Estimator, and Draughtsman, T. Piggott & Co., Ltd., Birmingham.

Barwick, John Clapham, Designer, Estimator, and Draughtsman, Clapham Brothers, Ltd., Wellington Foundry, Keighley.

Dawe, John Herbert, Works Manager, Higginshaw Works of the Corporation Gas Department, Oldham.

Dawes, Wilfrid, Constructional Engineer, Woodall-Duckham Vertical Retort Company, 150, Victoria Street, London, S.W. 1.

Education Committee's Report to the Council.

The Gas Education Committee has pleasure in submitting to the Council of the Institution of Gas Engineers its report for the year 1929-30.

The Education Scheme, as modified to meet the requirements of the isolated Student, has now been put into the form of definite Regulations, copies of which can be obtained from the Secretary of the Institution. Any Student of Gas Engineering or Gas Supply, though strongly advised in his own interests to study in Schools and Colleges approved by the Board of Education and its sister organizations in Scotland and Ireland, can now decide for himself how he will acquire the knowledge and training required to pass the Examinations and, be it added, to become a well-educated member of the staff of the Gas Industry. That, and not merely the securing of Certificates or Diplomas, is the purpose for which the Gas Education Scheme was provided and is being carried on. It is somewhat early to gauge the effect of this change, but the enquiries received from Students show a healthy desire to become fully conversant with the provisions of the revised Education Scheme. The number of entries of Internal Students this year is almost identical with that of last year, but the figures for External Students showed a decrease.

MAJOR COURSES.

Year.	Internal Candidates.	External Candidates.	Total.
1924	37	19	56
1925	59	80	139
1926	100	63	163
1927	117	101	218
1928	133	119	252
1929	239	108	347
1930	241	71	312

As the facilities for instruction in approved classes have been extended, the number of Internal Candidates has shown continuous growth. An even greater rate of increase may now be anticipated, since the Examinations conducted under the Scheme are the recognized means of entry to the various classes of membership of the Institution.

In the recent Examinations the number of Candidates in Gas Supply was only 152, a figure far below what might reasonably be expected from the large number of men employed on this side of the Industry. There seems to be a great need for arousing the interests of young Gas employees in educational matters, the value of which is not yet fully appreciated. Gas Engineers and Managers could do much to change this, by explaining the matter to their men and encouraging them to enter upon regular courses of study and by calling for reports upon their progress and taking into account, when fixing salaries, granting promotion or filling vacancies, not only results, but the fact that the young men are seeking to improve themselves by education. Such an interest in the work done by the juniors to prepare themselves for later responsibilities should do much to make them realise that their seniors recognize the value of a good general and technical education.

During the year approval was given to 12 new Courses, comprising :—

5 Courses in Ordinary Grade Gas Engineering.
3 Courses in Higher Grade Gas Engineering.
2 Courses in Ordinary Grade Gas Supply.
2 Courses in Higher Grade Gas Supply.

The Minor Grouped Courses in Gas Supply Practice and in all three Grades of Gas Fitting showed considerable increases in the number of candidates, there being 249 more entrants this year than last. The number of entries for the last three years are given in the following table.

MINOR COURSES.

Subject.	1928.	1929.	1930.
Gas Works Practice	16	12	6
Gas Supply Practice ...	71	89	106
Gas Fitting, Grade I ...	302	428	531
Gas Fitting, Grade II ...	136	282	403
Gas Fitting, Final	42	119	133
TOTAL	567	930	1179

The increase in the number of Gas Fitting Students from 480 to 1,067 in two years, is very gratifying. As 1,491 candidates in all entered for the Examinations in Gas Subjects in the year—an increase of 214 over the figure for the previous year—satisfaction is to be found in the continuous growth in the number of entrants, but there is still much to be done before the number of Students taking classes can be said to be reasonably proportionate to the number of employees in the Industry. Three Minor Courses in Gas Supply Practice and one in Gas Fitting were approved during the year.

The revised Education Scheme provides that only Students in Minor Courses approved by the Institution will be accepted as Internal Candidates for the Examination of the City & Guilds of London Institute and be able to secure endorsed Certificates. Many Colleges have not yet applied for approval, but will doubtless do so before the classes start next session. A closer relationship may be anticipated in the future between the interests of all those concerned with Gas Education, and there will probably be a greater incentive for students in Minor Courses to proceed later to take Major Course Certificates.

During the year Mr. Walter Hole resigned from the Organising Secretaryship of the Education Scheme and it is the desire of the Committee to place on record its appreciation of the valuable services he rendered. His enthusiastic endeavours to make the provisions of the Scheme known to the young men of the Industry, and his painstaking handling of a large amount of detailed work and correspondence, are services which have proved of great value and deserve the gratitude of the whole Industry. With his resignation the Organising Secretaryship was left in abeyance and the secretarial work was discharged by a member of the Staff of the Institution. As from the date of this Report, however, the entire administrative and secretarial responsibility of the Scheme will be undertaken by the Secretary of the Institution.

F. W. GOODENOUGH,
Chairman.
J. R. WILLIS ALEXANDER,
Secretary.

APPENDIX A.

LIST OF DISTRICT COMMITTEES, WITH NAME OF CHAIRMAN AND SECRETARY.

District.	Chairman.	Secretary.
Eastern ...	F. Prentice ...	E. F. Keable, Engineer & Manager, Gas Works, Southtown, Great Yarmouth.
Irish	J. D. Smith ...	G. Airth, Gas Works, Dundalk.
Lancashire ...	W. J. Smith, B.Sc.	J. Alsop, Gas Street Gas Works. Bolton.
Midland ...	F. C. Briggs ...	H. R. Hems, Gas Department, Council House, Birmingham.
North of England	C. Dru Drury...	H. Lees, J.P., Gas Office, Hexham.

APPENDIX A.—*continued.*

District.	Chairman.	Secretary.
Scottish... ...	Dr. T. Gray ...	David Fulton, Gas Works, Helensburgh.
Southern (S.E.)	... ...	T. H. Prater, Gas Works, Margate.
Southern (S.W.)	R. Robertson...	S. Hole, Gas Works, Bath.
Wales	H. D. Madden	O. Thomas, Gas Works, Pentre, Rhondda.
Yorkshire ...	J. Bridge ...	C. H. Chester, Gas Works, Wakefield.

APPENDIX B.

LIST OF CENTRES HAVING APPROVED MAJOR COURSES IN GAS SUBJECTS.

O.E. = Ordinary Grade Gas Engineering.
H.E. = Higher Grade Gas Engineering.
O.S. = Ordinary Grade Gas Supply.
H.S. = Higher Grade Gas Supply.
* = First two years of course.
† = Ancillary subjects only.

Bath Technical College	O.E.	H.E.	O.S.	—
Barnsley Technical College	O.E.	—	—	—
Birmingham Technical College	O.E.	H.E.	O.S.	H.S.
Blackburn Technical College	O.E.	H.E.	O.S.	—
Blackpool Technical College	O.E.	—	—	—
Bournemouth Municipal College ...	O.E.	H.E.	—	—
Bradford Technical College	O.E.	H.E.	O.S.	H.S.
Bristol Merchant Venturers' Technical College	O.E.	—	O.S.	—
Burnley Technical College	O.E.	H.E.	O.S.	H.S.
Cardiff Technical College	O.E.	H.E.	O.S.	H.S.
Coventry Technical College	O.E.*	—	—	—
Derby Technical College	O.E.	H.E.	—	—
Dewsbury Technical College	O.E.	—	—	—
Dublin Municipal Technical Schools ...	O.E.	—	O.S.	—
Dundee Technical College	O.E.	H.E.	O.S.	H.S.
Edinburgh Heriot-Watt College ...	O.E.	H.E.	O.S.	H.S.
Glasgow Royal Technical College ...	O.E.	H.E.	O.S.	H.S.
Halifax Technical College	O.E.	—	—	—
Huddersfield Technical College	O.E.	H.E.	O.S.	H.S.
Hull Technical College	O.E.	—	O.S.	—
Leeds Technical College	O.E.	H.E.	O.S.	—
Liverpool Technical School	O.E.	H.E.	—	—
LONDON :				
East Ham Technical College ...	O.E.	—	O.S.	—
Polytechnic, Regent Street... ...	O.E.	H.E.	—	—
Polytechnic, Tottenham	—	—	O.S.	—
Sir John Cass Technical Institute ...	O.E.	—	—	—
Westminster Technical Institute ...	O.E.	—	O.S.	H.S.
Luton Evening Institute...	O.E.	—	O.S.†	—
Manchester College of Technology ...	O.E.	H.E.	O.S.	—
Newcastle-upon-Tyne Rutherford Technical College	O.E.	H.E.	—	—
Plymouth Technical College	O.E.	—	—	—
Salford Royal Technical College ...	O.E.	H.E.	O.S.	H.S.
Southampton University College ...	O.E.	H.E.	O.S.	—
Stoke-on-Trent Technical College ...	O.E.	—	—	—
Wigan Technical College	O.E.	—	—	—
Wolverhampton Technical College ...	O.E.	—	O.S.	—

APPENDIX C.

LIST OF CENTRES HAVING APPROVED MINOR GROUPED COURSES IN GAS WORKS PRACTICE, GAS SUPPLY PRACTICE, AND APPROVED COURSES IN GAS FITTING.

GAS WORKS PRACTICE.

Bath Municipal Technical College.

GAS SUPPLY PRACTICE.

Bath Municipal Technical College.
Birmingham Central Technical College.
Bradford Technical College.
Cardiff Technical College.

LONDON :

Acton and Chiswick Polytechnic.
Borough Polytechnic.
East Ham Technical College.
Croydon Technical College.
Goldsmiths' College.
Hackney Institute.
Tottenham Polytechnic.
Westminster Technical Institute.

Newcastle-upon-Tyne Rutherford Technical College.
Plymouth Technical College.
Tunbridge Wells Technical College.

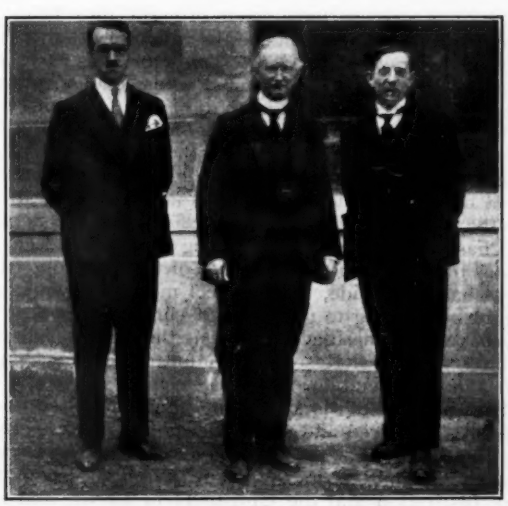
GAS FITTING.

Bath Municipal Technical College.
Birmingham Central Technical College.
Bournemouth Municipal College.
Bradford Technical College.
Brighton Technical College.
Cambridge Gas Company.
Cardiff Technical College.
Cheltenham Technical School.
Dudley Technical College.
Eastbourne Technical Evening School.
Exeter Gas Light & Coke Company.
Harrogate Technical School.
Huddersfield Technical College.
Hull Technical College.
Leamington Spa Technical School.
Leeds Technical College.

LONDON :

Chiswick Polytechnic.
Croydon Central Polytechnic.
East Ham Technical College.
Finchley Evening Institute.
Hackney Institute.
Tottenham Polytechnic.
Wandsworth Technical Institute.
Watson House, Nine Elms Lane.
Westminster Technical Institute.

Newcastle-upon-Tyne Rutherford Technical College.
Newport Technical College.
Ramsgate Technical Institute.
Stoke-on-Trent Technical School.
Tunbridge Wells Technical Institute.
Wakefield Technical College.
West Bromwich (Kenrick) Technical College.
Weston-super-Mare School of Science and Art.
Wolverhampton Technical College.



"Verb. Sap."

The Institution and the University:
Teaching and Research.

By J. W. COBB, C.B.E., B.Sc., F.I.C.,

Livesey Professor of Coal Gas and Fuel Industries in the University of Leeds.

It is an interesting coincidence that the first Annual Meeting of the Institution of Gas Engineers following the granting of its Charter should be held in the city where the first Chair in Gas Engineering was established in a British University, and it has been thought fitting to mark that occasion by giving some account of those activities in which the Institution and the University have been associated. Hence the title of my paper, in which I shall attempt to give some account of what has been done in the teaching of the principles which underlie the practice of the profession of Gas Engineering and of research into the problems of the gas industry, which are constantly growing in number and importance as the industry develops.

Neither as regards teaching nor research will it be possible to cover the whole ground. The gas industry has been increasingly conscious in recent years that the nature of its activities, both inside the works in the carbonization of coal for the making of gas, coke, and bye-products, and outside in their distribution and utilization, demand special knowledge and its intelligent application from the members of the staffs concerned, a knowledge which day to day experience is not sufficient to impart, but which can only be acquired by systematic instruction planned for the purpose. Hence have arisen those schemes of training on which the Institution can congratulate itself, which provide for training in gasfitting and, on an ascending scale, in the subjects of Gas Engineering practice, including both manufacture and distribution, and aim at securing and certificating standards of educational attainment in a comprehensive manner throughout the industry. This training is based upon attendance at evening classes at Technical Institutions by students otherwise occupied during the day. Of this good work I can speak in terms of appreciation, but must leave it to others to speak with that first-hand knowledge born of experience, which is necessary for its adequate treatment.

I am called upon to deal more particularly with the training for the profession of Gas Engineering given at the University to a class of entrants to the profession who are prepared to give up three or four years entirely to the studies adjudged necessary for the purpose.

Again, as regards research, it will be seen on studying the records of the Institution that Research Committees with various objects have been brought into being at different times, and that outside the range of collaboration with the University of Leeds excellent work has been done in various directions. The most conspicuous example which comes to my mind is that of the Committee on Refractory Materials on which, in association with the Society of British Gas Industries, the Institution set out to raise the standard of quality in the refractory materials used in the construction of furnaces and settings. It did so by the formulation of agreed specifications, and in other ways has done excellent pioneering work of which the industry may be proud. The scope of these various Committees has been wide, with subject matter varying from wrought iron tubing to gas fires for clinical purposes. So many have been these activities that the Council has now appointed a General Research Committee for their supervision and co-ordination.

When the research is such that the co-operation of the University is desired and the services of full-time research workers are required, the work is allotted by the General Research Committee to the Joint Research Committee of the Institution and the University of Leeds, and it is more particularly with this work that I shall attempt to deal, under the heading of research.

TEACHING.

Reverting now to teaching and the University training of entrants to the Gas Engineering profession, I would suggest that this development is interlocked with that of the industry itself, and with the raising of the status of the Gas Engineer. Indeed, I think it may be taken as an unchallengeable proposition that the stage of development reached by an industry or the professional status of its responsible leaders, managers, and technical experts, may be gauged from the standard of general and professional education which it has the courage and sagacity to demand in its recruitment from the youth of the day. This proposition is consequential upon another of equal validity that the progress of any industry or profession will be largely dependent upon the extent to which it succeeds in attracting to its service first-class human material. These propositions are partly from stress of circumstances much more clearly recognized as true than ever before, and the industry or profession which is low in its educational and intellectual demands, or slow in its recognition of merit or services by promotion or other reward, stands little chance of that survival which is reserved for the fittest.

The gas industry was started in order to work a novel and ingenious process for lighting purposes, dependent upon the expulsion by heat of illuminating gas from coal. The scope of its operations has widened until it is now the most highly developed and efficient system known for utilizing the chemical and thermal potentialities of coal for supplying to the community heat, light, and power and invaluable bye-products. The growing necessity for efficiency and economy in the use of coal, the increasing demand for smokeless fuel, gaseous and solid, and for liquid fuel, especially motor spirit, are responsible for the developments which the industry has undergone and is undergoing to-day. But such development means an increasing complexity in processes, appliances and their operation, and the combination of chemical and engineering skill called into play has created the profession of the gas engineer. The development is along scientific lines and scientific training is essential for its fulfilment.

It was the clarity of vision of some of the more advanced gas engineers which brought them to the conclusion that the most fitting memorial which could be raised to the memory of the great leader, Sir George Livesey, whom they had just lost (1910), was one which should stimulate this conception, and the gas industry, by endowing the Livesey Chair in the University of Leeds for the express purpose of giving to intending entrants to the gas engineering profession a scientific training which should meet their needs. The University of Leeds was indicated by the fact that it had already instituted the first Fuel Department in any British University, and by the interest in the industry and its problems which had been already shown in no uncertain way by Professor Smithells, the Head of the Chemical Department. Professor Bone was the first occupant of the Livesey Chair, and I succeeded him in 1912.

The principle of training for the profession of Gas Engineering in the University, which forms the basis of all its teaching, may be expresssed in two propositions, one negative and one positive. It is *not* believed that the time of students during the three or four years of a degree or diploma course ought to be taken up in acquiring a knowledge of the minute details of gas engineering practice. It *is* believed essential to prepare a foundation which is sound enough and strong enough to carry any superstructure of detailed knowledge which practical experience may lay upon it. The course is there-

fore in essence one in the scientific principles on which the practice of gas engineering is based and brings in the treatment of various branches of practice in such a way as to bring out the operation of such principles. It involves the study of Chemistry, Physics, Mathematics, and General Engineering in the first stages of the course, followed by the more detailed study of the chemistry and physics of gases. Then come the courses in the more specialized and professional subjects, such as carbonization, heat interchange, thermal efficiencies, pyrometry, calorimetry, and special courses on gas manufacture, purification, coke-oven practice, distribution, and the like. For the more specialized courses we owe much to the assistance of lecturers appointed from time to time for the purpose, recognized experts in their particular subjects who bring into the University Department the knowledge and spirit of the most modern industrial practice.

For two out of the three months of each long vacation the student goes into a works, and there again we have to thank the industry for its willing co-operation. In the first long vacation it is usual to go into a general engineering works, and in subsequent vacations to a gasworks, or some works dealing with manufacture and installation of plant for gas engineering purposes. The contacts a student makes in this way are useful, not only on account of what he learns of gas engineering, but because they familiarize him with the works atmosphere and sometimes prepare the way for an appointment when his University training is completed.

Three years brings many of the students to the end of their course with a degree or diploma. Some stay for a fourth year in order to add to the systematic laboratory training they have received some experience in methods of research. This fourth year is essential for a student who looks forward to a research post, or one who desires to specialize on the chemical side. It is less essential for a student who has in mind a more general or executive position. It is our belief that students who have undergone this training ought to be capable of developing after entering the industry, in different ways, according to their tastes and opportunities, in order to fill responsible posts of different kinds which the complexities of modern organization provide and are even more likely to provide in the future.

Roughly speaking, I think the case for University training in Gas Engineering might be put in this way. A student who has had the opportunity and time during a full University course, to bend his energies while his mind is young and elastic to saturating himself with the scientific principles of his industry will find it possible to acquire practical and detailed information comparatively easily and quickly on entry into industrial life, and to understand and initiate. On the other hand, if that period of rigorous scientific training is omitted, the acquisition of its implied knowledge and scientific habit of mind in after life can hardly ever be successfully undertaken. The demands in detail of daily duty are too great to permit of it, and continued mental concentration upon a line of thought which is not obviously connected with a problem of the moment calls for a sustained effort which few can, or will, make.

The results so far obtained by the training of Gas Engineers along the lines indicated have so far been extremely gratifying in one sense, that our men after training have been readily taken up and are already beginning to make their mark in the industry. In another sense they are less gratifying because the numbers coming forward are not sufficiently great to allow of our filling the posts which are offered. The number of full time students in the Department rose from 5 in 1910 to a maximum of 38 in 1919, the exceptional year after the war, and is now 23. We hope that the idea of sending promising young men for University training in Gas Engineering will be stimulated by such expressions of faith as that forthcoming from the recent endowment of the valuable Cartwright Holmes Scholarship by Mr. P. F. Holmes and Mr. D. M. Henshaw, following as it does upon a similar endowment made in 1915 by Sir Corbet Woodall of the scholarship which bears his name. Each of these scholarships provides for training in Gas Engineering at the University a selected candidate, who declares his intention of entering the profession of Gas Engineering.

RESEARCH.

Apart from the work of the Joint Research Committee, with which I shall mainly deal, the Institution has supported the continuous prosecution of research work in the University under the direction of the Livesey Professor from the year 1907 by the endowment of the Gas Research Fellowship. This was originally of the value of £100 per annum, increased later to £200 per annum, and the report on the work of the Fellow is made each year to the Institution. The work has been of a varied character. A Forshaw studied the comparative radiating power on combustion of CO and hydrogen, and H. Hartley the electrical condition of surfaces during the combustion of gases. H. Hollings was the next holder of the Fellowship. He worked principally on thermal phenomena in carbonization, tracing the stages of heat evolution and absorption which accompanied the gradual rise in temperature of coal undergoing carbonization. Towards the end of the war period, results were published on an examination which had been made of the conditions under which benzene and toluene suffered decomposition during carbonization. This work had been carried out by Dr. S. F. Dufton, one of H.M. Inspectors of Schools, who had been partially released from his duties for the purpose, and worked as Honorary Research Fellow. There followed an investigation by A. C. Monkhouse, which aimed at providing precise information on the conditions of liberation of nitrogen and sulphur from coal as ammonia and sulphuretted hydrogen, with particular reference to the influence of temperature and of the surrounding gaseous atmosphere. The same theme was followed up by S. Pexton, who concerned himself more particularly with the gasification of coke in steam, and that led on to a study of the composition of the gas obtained when cokes prepared at different temperatures were gasified in currents of steam at gradually increasing temperatures and velocities. It was thought desirable to secure information as to how far the liberation of nitrogen and sulphur from a coal was influenced by the presence of inorganic constituents, such as occur in the ash, and this was the next stage in the work, undertaken by C. B. Marson. He was diverted to some extent from this theme by the remarkable qualities possessed by the cokes which he had prepared at different temperatures, containing additions of such oxides as lime, ferric oxide, and soda, and the most interesting part of his work was the establishment of the remarkable effect which these additions exercised, in multiplying many times the rate of gasification in steam or CO_2 of the cokes containing them. This was the commencement in our laboratories of the investigation of the reactivities of cokes. It was followed up by J. A. Sutcliffe, and later by F. J. Dent. The various factors affecting reactivity were studied, such as temperature and time of heating, the presence of different surrounding atmospheres, and the transformation of carbon. It was shown that different forms of carbon existed with different equilibrium positions in the reaction with carbon dioxide, and that the inert graphitic form producing unreactive coke was most readily formed in coals which fused easily on heating. This study is being continued in various directions as being of fundamental importance in nearly all carbonization and gasification work.

Reverting, then, to a line of investigation from which we had been diverted, J. J. Priestley carried out work and published results on the influence of inorganic constituents in coal on the liberation of sulphuretted hydrogen during carbonization in atmospheres of nitrogen and hydrogen, and A. H. Eastwood, the present holder of the Fellowship, is making a corresponding study on the liberation of nitrogen as ammonia.

Giving this list of the men who have held the Gas Research Fellowship in successive years, it may be added that they have gone forward from the Fellowship to amplify their services to the industry in positions of responsibility, H. Hartley, H. Hollings, and F. J. Dent being identified with Radiation Ltd., the Gas Light and Coke Company, and our own Joint Research Committee respectively. A more excellent record of service by the holders of one Fellowship could hardly be desired.

JOINT RESEARCH COMMITTEE.

We now come to the work of the Joint Research Committee, which has borne several names during its career,

but has always attempted to serve the same purpose, the investigation of some matter of interest to the Gas Industry. The Committee was first formed in 1910 under the name of the Gas Heating Research Committee. It was constituted with an equal number of representatives from the Institution and the University, the original Institution representatives being Messrs. John Bond, J. H. Brearley, and Charles Wood, the University representatives being Professor A. Smithells, W. A. Bone, and J. B. Cohen, Professor Smithells being the first Chairman.

The Committee made its mark at the outset by undertaking the first systematic examination of the working of the gas fire and the determination of its radiant efficiency, placing before the gas industry information of a definite and eminently useful character. The method thus devised and used for the determination of radiant efficiency depending primarily upon the construction of what might be described as a polar curve radiation from the fire, is now generally known as the Leeds method, and in slightly modified form remains in use to this day in laboratories where the scientific testing of gas fires is undertaken. E. W. Smith, following upon E. Drugman, was the Research Chemist to the Committee at this period, and his name will always be associated with the work then carried out, which was reported to the Institution in 1909.

The work next undertaken was on the subject of ventilation, and for this purpose, the Joint Committee on Ventilation Research was appointed in 1913, in the year following my appointment as Livesey Professor, Professor Bone having gone to London. It was felt that in order to secure results which might be of permanent value, though perhaps not immediately applicable without modification to actual practice, it would be necessary to carry out a series of experiments under carefully standardized conditions. For this purpose a special ventilation building was constructed—really a room within a room—in such a way as to counteract fluctuating atmospheric disturbances. The building served its purpose well and is still in use for similar tests.

The quantitative ventilating effect of a gas fire was determined as well as the amount of the benefit obtainable by the use of auxiliary air inlets round the fire. The experiments were made with a flue 1 ft. square in section. There is a revived interest in this subject to-day and attention may very well be called to the three reports of the Ventilation Research Committee issued in 1914, 1915, and 1916 on account of the data there accumulated.

It must not be forgotten that a gas fire in a room serves a double purpose. Primarily it is a heating agent, but its function in securing ventilation is almost as important, and what the gas fire can do in this respect was determined at that time. Ventilation by lighting burners and the movement of air effected by flues of different diameters as the internal temperature was gradually increased was also subjected to examination. The Research Chemist who was responsible for some ingenious devices employed in the course of this investigation was Mr. William Harrison. The Committee although still in existence did not engage in other work until it became obvious that definite information ought to be obtained respecting the real effectiveness in gas appliances of the different grades of gas which it was reasonably possible to manufacture and distribute. War conditions had been responsible for variations from a standard practice dictated by statutory requirements for gas based on illuminating power in a flat flame burner. These requirements had vanished for the time being, owing to the necessity for taking benzene and toluene out of the gas and their reimposition was unthinkable. At the same time, nobody knew enough about the behaviour of different kinds of gas and their relative efficiencies to be able to say with any real grounds for his assertion within what limits Gas Companies and Authorities could alter their standard of gas supplied without prejudice to the consumer. Systematic experiment was urgently required in order to provide this information.

At a meeting of the Joint Committee held at the University of Leeds on Dec. 21, 1916, it was resolved to prepare for circulation to the Committee and later to the Council of the Institution a memorandum to that effect, and this having been done, the Council subsequently appointed a large and representative Gas Investigation Committee (the Joint Committee acting as Research Sub-Committee) for the purpose of investigating "The Relative Efficiency in Use of Different Grades and Compositions of Gas." Mr. J. W. Wood was appointed Research Chemist for this work, and the first Report was presented to the Institution at a meeting held on Oct. 17, 1918, with Mr. S. Glover in the Chair.

Rich and poor coal gas, gas made by steaming in vertical retorts and water gas, gas to which nitrogen and CO_2 had been added in varying amounts, as inert constituents, were all subjected to trial at different pressures and rates of consumption in three standard appliances, the ring burner for heating water, the gas fire for heating a room by the emission of radiant heat, and the incandescent lighting burner. It was shown over what a considerable range the calorific value of gas per cubic foot could be altered without materially affecting the results obtainable in ordinary appliances, so long as the same number of heat units was delivered. These results formed the subjects of the 1st, 2nd, and 3rd Reports of the Gas Investigation Committee (and its Research Sub-Committee), and were presented in 1918-20. The information so obtained and conveyed was accepted as authoritative by the gas industry, and also by Sir George Beilby, who, as Chairman of the newly-constituted Fuel Research Board, had been asked by the Board of Trade to make recommendations on which the new Gas Act was to be based. The Gas Regulation Act of 1920, giving the gas industry a degree of freedom in the choice of its methods of manufacture which are nearly all that it could desire, embodied in effect these recommendations. According to the new Gas Act, the Company or Authority was placed at liberty to choose its standard, but a close adherence to that standard as defined by calorific value was insisted upon, and the recording gas calorimeter was as soon as possible to be made the official instrument, on the records of which penalties for deviation from standard were to be based. It was plainly desirable for the gas industry to know exactly what the behaviour under working conditions would be of such recording calorimeters as were available, and might be recommended for the purpose. So it came about that the next work undertaken by Mr. Wood for the Committee was a thorough examination of the Simmance recording calorimeter. The various sources of error were examined in a gas-works laboratory (loaned for the purpose by the Birmingham Corporation Gas Department), and a report was made in great detail in order that the industry might know what could be expected from the instrument in use, and so that the nature and extent of the difficulties encountered by the designers and users of such an instrument as a recording calorimeter might be appreciated by all concerned. The results were presented in the 5th Report, and it may for convenience be noted here that another recording calorimeter received a similar searching examination—the Fairweather recording calorimeter (see 8th Report, 1923); the widely used Beasley recorder was also subjected to systematic testing, in order to determine its characteristics (5th Report). The study made of the different grades of gas in heating and lighting appliances had impressed upon the Committee the importance of the degree of aeration of burners, and Mr. Wood's attention was directed at the first opportunity to a study of aeration and air injection. For preliminary tests an apparatus was designed of the utmost simplicity, which could be readily reproduced and was made in glass. In that way some general results were obtained (9th Report). It was always in mind that extension of the results so obtained to the problems of practice arising in the design and use of burners, would be made, and for that purpose a careful examination was next made of the aeration accompanying the use of gas in several typical burners, such as ring burners, those of the gas fire (11th Report) and lighting burners (13th Report). In this connection a method of determining the specific gravity of gases, which is so important in aeration, by balanced columns of gas and air, was examined, and found to be both reliable and convenient (13th Report).

Attention was then turned to another aspect of the use of gas appliances. A careful examination was instituted of the nature of the products of combustion from such appliances, and particularly to the investigation and determination of such products of incomplete combustion as carbon monoxide, when they were produced, in quantities

however small. This investigation was intended to ensure that the gas industry should be as completely informed as possible on the hygienic as well as the thermal position occupied by gas appliances, a matter plainly of the utmost importance and one in which it is easily possible to make mistaken statements in good faith.

To begin with, a reliable and accurate method for the determination of such small quantities of carbon monoxide had to be found, and modified in detail to make it suitable for these tests (15th Report). Typical appliances had then to be tested under conditions of normal, low, and high aeration. The gas fire, the ring burner, the griller, the surface combustion burner, and the geyser were examined in turn (17th, 19th, and 21st Reports), and lighting burners are now under examination. Generally speaking, the results disclosed how small were the quantities of carbon monoxide produced in the normal use of modern gas appliances, particularly when the inner cone of the Bunsen flame was not distorted, but indicated that in an appliance like the geyser, the use of an excessive amount of gas was to be carefully guarded against, as being liable to give carbon monoxide in quantity.

For all this part of the Committee's work, Mr. J. W. Wood has acted as Research Chemist, assisted in recent years by Mr. G. B. Howarth. When it became plain that the gas industry was to be at liberty, under the new Gas Act, to use those methods for the production of gas which were most efficient and economical, it was decided to add another side to the Committee's work, and while continuing the investigation of the efficiency and behaviour of appliances, to make an investigation of the processes of manufacturing gas. It was particularly desirable to have figures for the thermal efficiency in operation of the different processes used in gas production, and to explore particularly any modern methods promising increased efficiency. A commencement in this direction was facilitated by the offer by Mr. Lawrence Hislop and his Board of a new setting of Glover West retorts at Uddingston for the purpose of investigating the steaming of continuous vertical gas retorts. Dr. A. Parker was placed in charge of this work, and results were forthcoming in the 4th Report, 1920. Such steaming may be regarded in one sense as the manufacture of water gas in the retort, and it was evidently desirable to know for this and other reasons, what was the efficiency of manufacture of water gas made from coke in a separate generator. (The efficiency of manufacture of straight coal-gas had been ascertained at Uddingston by working the vertical retorts without steaming.)

The Birmingham Corporation Gas Department offered the use of a Humphreys & Glasgow blue water gas plant at Adderley Street, and Dr. Parker, with his staff, worked for some years at Birmingham. Tests under working conditions of the blue water gas plant having been made and reported (6th Report) a parallel set of tests was commenced on the carburetted water gas plant at Windsor Street, with an attached waste heat boiler, and in the 7th Report, 1922, it was possible to compare the carburetted and blue water gas processes and to ascertain the economy effected by the use of the waste heat boiler. By the construction of thermal and chemical balance-sheets for these Uddingston and Birmingham tests, it became possible to trace what became of the heat units and chemical constituents of the fuel carbonized or gasified during the carrying out of the different processes.

In the study of the blue water gas process at Adderley Street, standard conditions of working as to depth of fuel, cycle of operations, &c., had been followed. A return was now made to this plant, and the influence was ascertained of varying some of the conditions, more particularly the depth of fuel bed. It was so found possible to obtain useful information, submitted in the 10th Report, and incidentally to raise the efficiency and output of the Adderley Street plant.

In the reports made on water gas the considerable saving which might be effected by the use of a waste heat boiler was insisted upon, and the next set of experiments was made at the Windsor Street Gas-Works on a set of Woodall-Duckham vertical retorts, in order to ascertain what economy was effected in that type of plant by the use of waste heat boilers attached to it. At the same time, other data were secured on the working of the plant and gas producers, the results constituting the 12th Report (1924). This was the last test made by the Committee upon the working of a large-scale plant, although it is now commencing a similar test upon a setting of intermittent chamber retorts, kindly placed at its disposal for the purpose by Mr. Grogono and the Croydon Gas Company.

During the last few years, Dr. Parker and his assistants have been engaged on the Corbet Woodall experimental plant at the University of Leeds, in a more fundamental investigation into the factors which operate in determining the results of the carbonization of coal. These studies were made possible by the existence of the experimental plant which had been given to the University by Mr. Henry Woodall and his friends in memory of Sir Corbet Woodall. They were undertaken because it seemed desirable to get all the information possible as to what was the behaviour of coal at the different stages of carbonization and what results could be obtained from it by varying the conditions, such as those of temperature, time of exposure, and size of coal. It was desirable to know not only how the yields of gas were affected, but what were the quantities and qualities of solid and liquid fuels produced as coke and tar, what were the characteristics of low-temperature carbonization, and how it compared with partial rapid high-temperature carbonization. In order to get this information a medium-caking Nottinghamshire coal was carbonized through a wide range of temperature. The rate of evolution of gas and gas quality were determined at timed periods during the carbonization. The tar and ammonia were collected and the coke was examined. The influence of adding inorganic constituents was ascertained, and then a parallel series of experiments was made with a strongly caking Durham coal. The results have been reported in the 16th, 18th, 20th, 22nd, and 23rd Reports, 1926-29, the 22nd Report being given up entirely to an account of the properties (reactivities, points of ignition, &c.) of the cokes produced and some commercial cokes for comparison, while in a supplement to the 23rd Report a comparison of the medium caking and strongly caking coals has been made in the light of these experiments and laboratory experiments already mentioned under the Gas Research Fellowship.

The important subject of blending has not yet been touched, although experiments have been planned. The most recent piece of work undertaken by the Committee has been the examination of the cracking of creosote and gas-oil mixtures, the interest of which is obvious at the present time. A memorandum on this subject has already been submitted, and a report will, it is hoped, follow in November. The side of the Committee's work concerned with gas manufacture has been from the time of the 4th Report until that of the 22nd in immediate charge of Dr. A. Parker, and since then of Dr. F. J. Dent, while Mr. H. Kerr, Mr. F. S. Townsend, Dr. A. C. Monkhouse, Dr. C. B. Marson, and others have been research assistants. It need hardly be said how fully the Committee realizes its indebtedness to its research staff, now numbering, with two recently authorized additions, ten members, and particularly to Mr. Wood and Dr. Parker for anything it has been able to do. The Committee has, moreover, been exceedingly fortunate in that its deliberations were guided so admirably and for so long a period by Professor Smithells as its first Chairman, and that when he resigned, in 1928, so eminently suitable a successor to him was forthcoming in the person of Mr. Thomas Hardie. Apart, too, from the Chairman, we owe much to the spirit which animated such early members of the Committee as Mr. Bond, Mr. Brearley, and Mr. Charles Wood, and to the encouragement which has always been given to the work by the President of the Institution for the time being. The first report of the Gas Investigation Committee was presented with Mr. Samuel Glover in the chair, and last November when, for the first time, a special Aumumn Meeting was arranged for the reception and discussion of the reports on research work, it was Mr. C. S. Shapley who presided.

EFFLUENTS AND AMMONIA.

It seems right that mention should be made here of research work which has been undertaken recently by the Institution through its Liquor Effluents and Ammonia Sub-Committees, with Mr. C. F. Botley as Chairman,

since Dr. Monkhouse, the Research Chemist, and Mr. Etheridge, his assistant, are both members of the staff of the Joint Research Committee and of the University, while Dr. Parker has played an active part in the work of both Committees, and I have been associated with them as Secretary.

The Ministry of Health has, for various reasons, become more insistent upon preventing the pollution of streams, and the gas industry has shown its willingness to co-operate by the formation of the Effluents Sub-Committee, which is setting its hand to find out how gas-works operations may be conducted so as to produce as little effluent as possible with the minimum quantity of harmful constituents, and how the treatment and disposal of the effluent may be best effected.

The work of the Committee has been partly advisory and partly experimental. As a start the best information available to us on the subject was summarized by Dr. Parker and circulated in the 1st Report (1927) for the information of Gas Engineers, and since that time, all sorts of questions addressed to the Committee have been dealt with mainly by Mr. Botley or by Dr. Monkhouse. Willing acknowledgment has been made of the services so rendered.

Experimental work has been carried out at Hinckley and Coventry, through the good offices of Mr. Lee and Mr. Langford respectively. The advantages of securing a rapid initial separation of tar so as to minimize its contact with the warm liquor and consequent contamination of the latter has been demonstrated by the use of a Lodge Cottrell electrostatic tar separator, kindly loaned us for the purpose, and by a spray washer fixed by Messrs. Woodall-Duckham. This work continues, along with a laboratory investigation of the extraction of phenol from liquor by solvents with special reference to gas-works conditions.

Results have been submitted in four reports of the Effluents Committee, including a memorandum by Dr. Parker on phenol extraction, and one by Dr. Monkhouse on modern German practice.

The Ammonia Sub-Committee was formed in the face of the unfortunate economic situation brought about by the extension of synthetic ammonia production. It was to review the situation and make recommendations on research work or other matters. Sectional reports have been prepared by various members of the Committee. Some of these have dealt with improvements possible by the better working of existent standard plants and processes. Such was the useful paper by H. Hollings and S. Pexton, entitled "Economies in the Recovery of Ammonia by the Indirect Process," which was published in the first report in June, 1929. Other sectional reports presented at the Autumn Meeting, 1929, dealt with the Burkheiser, Cobb, and Liquid Purification Processes. One on the making of ammonia sulphate by the use of calcium sulphate is awaiting publication.

So much expensive experimental work has been and is being done on ammonia processes in this and other countries that the Committee has not yet felt justified in asking the Institution to support experimental work of its own in any particular direction.

In these two Committees, Effluents and Ammonia, the Institution has the advice not only of Gas Engineers and Chemists who have interested themselves in the subject, but also of Dr. Bailey, until recently Chief Alkali Inspector, Dr. H. T. Calvert, of the Ministry of Health, and Dr. Parker, of the Department of Scientific and Industrial Research, who bring special knowledge and experience to bear on the questions under consideration.

Finally, may I say that on the value of the work described above, it is rather difficult for me to speak, but the Transactions of the Institution and other records of meetings devoted to gas affairs contain ample testimony from outside authorities, such as Sir Dugald Clerk and the late Sir Geore Beilby, and willing witness borne by Gas Engineers on numerous occasions. The working of gas processes and appliances is much more thoroughly understood nowadays than it was 20 or even 10 years ago: efficiencies have been raised and economies effected, and the industry is able to look forward to the future with confidence in its ability to develop rationally and along lines indicated by scientific knowledge and principles. It is not too much to claim some share for the collaboration of the Institution and the University in the responsibility for this record of progress, and to hope that the partnership may continue in successful effort.

DISCUSSION.

The PRESIDENT: We are very much indebted to you, Prof. Cobb, for this very interesting communication, which you have been good enough to summarize, and I am sure the members will read it with great interest, for it embodies the history of the Institution and the University.

I will ask Dr. E. W. Smith to speak on this paper first, because he, too, has been included in the Birthday Honours List, having been made a Companion of the Most Excellent Order of the British Empire.

Dr. E. W. SMITH, C.B.E. (who was received with applause), said: I wish to thank you, Mr. President, for your kindly reference. As an old research worker at Leeds University—probably one of the earliest—I have very happy recollections of my association with it. The University is to be congratulated on having adopted a policy in its early days of specializing in the problems of different industries. It has the gas industry, the leather industry, the dyeing industry, and the rest (gas not being a "dying" industry), and it has been fortunate in adopting the gas industry. On the other hand, the gas industry was fortunate in adopting the University. It might have done a great deal worse in other universities, because at the time of this adoption the latter were not looking with favour on "trades," as these industries were termed; and Leeds University was not considered to be quite amongst the first flush of respectable universities when it decided to assist industry by training technical men for industries after the technical men had got their scientific training. Hence Leeds is to be congratulated, and the University is to be congratulated. A thought occurred to me while listening to Prof. Cobb—I hope he will put me right if I am not quite discreet—and it is this. The science of gas engineering is developing so rapidly, the gas industry itself is developing so rapidly, that I wondered whether the courses in gas engineering are subjected to a thorough review from time to time—not at too frequent intervals—with a view to ensuring their suitability and applicability to the men of to-day or the men of (say) five years hence. It is vital that the men who go to Leeds University or any other university to train themselves for taking up the work of an industry should be trained in the work of to-day and the work of to-morrow, rather than in the work of twenty or thirty years ago. From my knowledge of Leeds University—I was not trained there, but I know what the courses were—those courses were thoroughly up-to-date, but I should like to be assured that they are subjected to review by the industry, as well as the University, and that they include not only the training that is necessary for a gas engineer to run a works efficiently, but also the training necessary for carrying on the highest grades of research work, and some training in economics and practical engineering. I wondered what effect the new Charter, and the qualifications for membership of the Institution, have had on the training at the University—whether it has been necessary, or if it has been thought advisable to consider whether it is necessary, to modify the courses in order to fit them in with the higher standard of engineering needed, eliminating to some extent chemistry and the other sciences.

SCIENTIFIC TRAINING AND PRACTICAL APPLICATION.

It is gratifying to look around and to see such men as Hartley (the Chief Chemist to Messrs. Radiation, Ltd.), Forshaw (Chief Chemist to Messrs. R. & A. Main, Ltd.), Hollings, and many others who are getting into the industry and assisting in its technical development. I have a feeling, though, that we are not sufficiently enthusiastic in the profession in assisting a great many more men, who ought to come into the profession, in technical training. There is not enough constructive development in the universities in planning the courses for the students right through until they become gas engineers. The men who do come forward are few in number—they are moderately well selected; and it just happens. What can be done by the Institution, apart from offering these wonderful Fellowships, definitely to encourage men to come through and be trained as gas engineers? These men are to be the gas engineers of the future; and if we are to do anything at all, they must have a scientific training with a practical application.

Prof. A. SMITHELLS, C.M.G., F.R.S.: I said yesterday to an old friend at the "Yorkshire Post" office that I believe the public have no idea how indebted they are to me for the letters which I have not written to "The Times" [laughter], and I think that to-day I must really put you under the same sort of debt to me—in other words, I must refrain from saying a great deal which has been suggested to me by this meeting of the Institution of Gas Engineers. I dare say you can imagine what it means to me to come back to this city, where I spent so many years, and where I received so much kindness, and where most of my work was done. I am meeting kind friends

on every side, my old and esteemed friend, the first citizen of the city, who welcomed us this morning; my friend Mr. Shapley, with whom I had such cordial relations when I was in Leeds, and with whom I strove to work for the welfare of the industry here and elsewhere; and then I listen to Prof. Cobb giving us a record of what has happened since the industry came into association with the University. I hope every one of you will read carefully the record which Prof. Cobb has written.

A Man Free from Extravagance.

I remember seeing in the early days, a good many years ago, a picture drawn by that genial caricaturist who occasionally enlivens the sober pages of our Technical Press. It had to do with a discussion on some gas question, on which Prof. Cobb was speaking. In it he was represented as a marionette, and I was in a position concealed from the audience, pulling the strings. I am sure all of you who know Prof. Cobb will appreciate that that picture was not based on anything like the truth—that he is not a man likely to be influenced in that way. If ever I did occupy a senior position to him in relation to the gas industry, that state of affairs has long since been discontinued, and I can only appear to-day as a reflector of the wisdom that comes from his lips. He is, as you know, very well characterized by many virtues, one of which is a freedom from extravagance; and I can only say that I do not think a more temperate and true account of the relations between the industry and the University than he has given could have been presented.

Industries and Universities.

What could I say about it further? I could say a very great deal, but there are two points to which I would address myself particularly. In the first place, I should like to express to you how much it has meant to the University of Leeds to be associated with this great industry, and I should have liked delicately to have pointed out to you what I think are the particular advantages which you have gained by that association. I should have liked particularly to have stressed what I believe is the truth—that research on the problems of industry gains immensely when it is associated with a university institution, because of the great breadth of studies with which it comes into contact there. I should have liked to have spoken of a question which is often debated and on which I know that difference of opinion exists—whether it is better for an industry to set up its own independent institution or to join hands with a university and then enter into a combined attack. I personally have no doubt whatever as to which is the better course, so long as you can be sure that your university is entirely sympathetic; for I am sure it must be your experience, as it is the experience of those who engage in the more purely scientific work, that as soon as ever you begin to investigate a problem you are restricted, unless you are working in co-operation with experts in other fields of effort. At the outset you are sure to meet with questions which lead you to a field of investigation different from your own, and you are in want of information which you can only gain by going to experts in that particular field. So it has been in the history of this Department at Leeds. I am sure that everyone engaged in investigations there will testify to the necessity for making inquiries in some other corner of the University than his own. It may be a most unexpected corner; it may be in the region of higher mathematics; it may be in the region of biology—you never know where. In that way I believe the industry profits in a very clear, distinct, and unique manner by its contact with a university centre.

Raw Material for Training.

The second point on which I should like to address myself has been dealt with already by my friend Dr. Smith; it is the difficulty of getting a sufficient supply of material for training. There are explanations perfectly well known, I think, to those who are closely concerned with the conduct of universities. There is still, no doubt, a great reluctance in this country to run any risk of endangering those qualities which are most characteristic of British industry and British industrialists, and on which so much of their past success in the world has depended. They know you may have men of great learning but of great inefficiency, and how, when it comes to dealing with the practical problems of the world, there are qualities outside those which a university can provide which count so much in the solution of those problems and in the progress of the industry concerned. However, changes are taking place very rapidly. There are many revolutions in many fields, and I do believe that Prof. Cobb may look forward to a better response and to increasing numbers of young men coming to be trained to take their places and solve the problems of their day.

The Gate to Wisdom.

One other point I should like to mention. I was in Manchester last week, and there I heard some observations made by the American Ambassador which have been emphasized in various places, and which I think are worth a little notice. He said: "The University primarily is not so much the means by which knowledge is gathered as the means by which the student is given that mental training and discipline which enable him to acquire knowledge in his post-graduate education in the school of life. With his university training completed, the mind of the graduate is equipped with an added capacity to acquire knowledge, rather than with an added knowledge itself; and he goes into the world, other things being equal, better able to gather and retain facts—in other words, to acquire knowledge which, while different from wisdom, determines the material with which wisdom must deal. A university education, therefore, opens the gate to the realm of wisdom. Wisdom may be hard to define, as Mr. Baldwin recently said, but its possession is demonstrated by any mind which in its decisions segregates and weighs and properly interprets correlated facts."

There is no doubt a very great deal of truth in that, but I want particularly to say that in my opinion it is by no means the whole truth, and that it leaves out a very important part of the truth. It is considerations such as those, put so eloquently by General Dawes, which have led people in the past, and lead them in the present, to send their sons to those ancient centres of learning of which this country is so justly proud, where, it is believed—and rightly believed—the qualities which have been described by General Dawes are impressed upon the rising generations. But what is omitted from General Dawes' speech is this, that we live in a time of great economic anxiety, of great economic distress. It is now urgently important that the seats of knowledge should address themselves to the questions of the day, that they should bring themselves into the closest possible contact with industrial life, and see that those who enter upon industrial life are endowed, not merely with the virtues he describes, but with ordered knowledge of the scientific principles which underlie their work. The experience of the past is sufficient to emphasize this. Much can be done on the basis of an intelligent understanding combined with the other virtues which the industrialists ought to possess, but pray do not let us disdain this close contact with industry, the solution of practical problems. Let us have fundamental knowledge and fundamental research by all means, but beyond that we want the close contact with definite practical problems such as we have attempted to deal with in the past at the University of Leeds, and such as the gas industry will always supply us with in abundance.

In conclusion I would repeat what a great deal it has meant to me to be associated with this industry throughout the greater part of my life.

Prof. Cobb's Work for the Industry.

Mr. Thomas Hardie (Past-President of the Institution, and Chairman of the Joint Research Committee): I should like to express my appreciation of the very fine paper Prof. Cobb has given us, which includes a résumé of the work of the Research Committee during the last twenty years. Prof. Smithells has referred to the association of the industry with Leeds University, and I am sure that the advantage which has been derived by the gas industry from that association can only be gauged accurately by those who are able to measure the value of the work that has been done by the Committee for the members of this Institution and gas engineers generally. Prof. Smithells has also mentioned that Prof. Cobb has been very modest in writing this paper, and I should like to emphasize that for a long time the brunt of the work of the Committee has fallen to the lot of Prof. Cobb. I sometimes think we seem to imagine that we have some call on Prof. Cobb—that we can call upon him at any time to do this, that, and the other. He gives us his services so willingly that we are apt to forget that the work he does for us is done voluntarily, and that it is outside his usual work. Not only has he done very fine work in connection with research for the Institution, but he has rendered service of enormous value to the industry outside the Institution; and I cannot find words with which to express our debt to him for the work that he has done. [Applause.]

Prof. Cobb has mentioned the Research Staff, and I should like to say how satisfactorily their work has been done. We have been most fortunate in having obtained chemists who have thrown themselves whole-heartedly into the work from the very beginning; and the results of the investigations are due very largely to their great interest. The reports themselves will bear any amount of study—and it is only by a proper study that one can get the full value from them. As Chairman of the Committee I wish to make my own acknowledgment not only to Prof. Cobb, but to all the University members of the Committee, and to our President, who has had the honour of being appointed by the University as one of the representatives on that Committee.

Research at Leeds University.

Mr. C. F. Botley (Past-President): I should like to avail myself of this opportunity of bearing testimony to the great value which the gas industry receives from the association of the University of Leeds with its research work. It is perhaps true to say that even now there are some of our colleagues who do not altogether appreciate what they owe to research work. Probably they are unconsciously making use of the work that has been done in Leeds, and it is very certain indeed that in the last few years the whole aspects of gas economics have been changed by the operations associated with Leeds University.

We remember with gratitude our friend Prof. Smithells; and I feel that while we are at Leeds, the home of the University, we must pay a tribute also to its work, which has been carried on since 1912 by Prof. Cobb. I happen to be fortunate enough to have been associated with research work for some little time, and I regard it as a great privilege to work with Prof. Cobb and so many of those with whose training he has been so much identified. I am thinking particularly now of the matters to which reference is made in Prof. Cobb's paper, and I say without hesitation that the work which has been undertaken by the Effluents Committee and the Ammonia Committee would have resulted in failure if it had not been possible to associate the University of Leeds, and Prof. Cobb and his staff—Dr. Parker, Dr. Monkhouse, and others—with it. I feel that no words can express adequately our indebtedness to the University of Leeds and its staff for the assistance they have given to the gas industry.

Publicity and Financial Circumstances.

Sir ARTHUR DUCKHAM, G.B.E., K.C.B.: In connection with this very interesting paper by Prof. Cobb, which gives us the history of a magnificent achievement, and a great deal of promise for the future, I am more interested in the training of the men for the industry. In the first place, Prof. Cobb pointed out how relatively few men come forward for training as gas engineers, and has told us that he has his staff fully booked up, possibly for a year, and possibly for a longer period, before they finish their work at the University, with jobs at good remuneration. Surely, if there is this lack of men, it must be due either to bad publicity as to the availability of these jobs, or it must be due to the circumstance that the type of young fellow who comes forward into gas engineering has not the means to enable him to give four years of his life at the proper time without receiving remuneration. I would suggest to the Council that if this lack of men is due to want of publicity, then there is much work for them to do in encouraging publicity, to show that there is a real livelihood and a real future in the gas industry. If, on the other hand, the lack of men is due to shortage of funds, I would suggest that this training of young fellows for the gas industry is of such value and of such prime importance to the gas industry that it should not be too difficult to develop a further series of scholarships to support these young men while they are undergoing training. After all, a considerable amount of money is subscribed by the gas industry for publicity concerning gas supply and gas use. This human raw material of the gas industry is worthy of support; and I think that support might be given by all of us, if it is necessary, in somewhat the same way as it is given to the selling of gas.

In the training of men we have had some considerable experience, and we have had many excellent men coming through. As Prof. Cobb has said, to begin with the trainee must have a sound grounding in the principles of physics, chemistry, engineering, and so on, in order that he may become a gas expert or a fuel expert. This is essential, but I find that these trained men are of the greatest use to us in the industry—to firms such as my own, and also in the gas-works—because they have the power of observation which is often lacking in a man who is purely an operator. It is that power of observation which we wish to see strengthened in a university career; we want them to have the power to apply what they observe for the benefit of the industry, producing greater economy in working. I have just had an interesting talk with Prof. Smithells on this subject, in which I pointed out to him that there is something further which we should like to see encouraged in these young fellows, and that is imagination and the power to go beyond present knowledge.

Encourage New Ideas.

Dr. Smith stated this morning that we should not be taught the learning of thirty years ago, but that we should be taught the learning of to-day and should be prepared to absorb the learning of to-morrow. I would emphasize that you ought to encourage these young men to have ideas, be those ideas ever so mad; they should be taught to look ahead and to make proposals. I had no very strong technical education—I went up to King's College in the evenings—but I was blessed with imagination, and to-day I bring forward ideas and put them before my highly trained technical staff, who sometimes tell me that they are silly ideas. But when we get down to a close consideration of them we find they are based on a modicum of truth and have possibilities; and with the aid of the trained minds of the staff that modicum is made into something worth while. I am certain that there is the danger, in technical training as we have it, that we do not encourage imagination sufficiently.

Finally, we must have sound research; we must live for research. I am certain that nothing has been more helpful to the carbonizing industry than the wonderful research carried out at the Fuel Research Station at East Greenwich and at other places, and the continuation of that work will be absolutely invaluable to the gas industry, because it is only very rarely that in the works we can get absolute figures on which we can rely and on which we can base our data for the future, whereas the research institutions can get such figures. We are more than grateful to Prof. Cobb for his work and to the Institution for the building-up of this research work. Mr. Hardie and his colleagues on the Joint Research Committee have also given splendid service; and I am sure that none of us grudges either the time or the money devoted to the work.

The Importance of Education.

Sir FRANCIS GOODENOUGH, C.B.E.: There is a good deal that I should like to say on this subject, but I should ill requite the kindness that has been showered upon me at all hands to-day if I were to attempt to make a speech at this late hour. I will content myself by saying what a great pleasure it was to listen to the presentation of this extraordinarily valuable paper by Prof. Cobb and to the very charming and very valuable speech made by Prof. Smithells, and that I should like to associate myself with everything that has been said in appreciation of the work of the University of Leeds, especially of those two wonderful pioneers in technical education in the University—Prof. Smithells and Prof. Cobb. Education is a really important matter for the gas industry. It is more important to commerce and industry to-day than it ever was before; and I hope sincerely that this paper, and the discussion upon it, may be of great service in stimulating interest in the subject of education in this great industry. (Sir Francis indicated that he would add a written contribution to the discussion.)

"A Characteristically Modest Account."

Dr. C. H. LANDER (Director, H.M. Fuel Research Station, East Greenwich), in a written communication, stated: Although to my great regret unable to be present at the annual meeting of the Institution of Gas Engineers, I feel that I cannot allow the occasion to pass without saying a few words on the connection between the Institution and the University. I think an exceedingly useful purpose has been served by the characteristically modest account which Prof. Cobb has prepared on this important subject. The gas industry is one of the largest industries in the British Isles, and it is easily the largest chemical industry. Unlike some of the other chemical industries, it deals, not with pure raw materials, but with a material which contains countless different entities; and although by the operations of carbonizing or water gas making the products are simplified, they are still extraordinarily complex. Many chemical reactions occur during the processes used, and no single definite reaction such as occurs in many chemical industries controls the operations. I wish, therefore, to emphasize the remark made by Prof. Cobb—that it is essential to attract the best brains to the industry, and to give them the finest possible training in fundamental matters.

There is one phrase in the paper which has struck me very forcibly, and that is Prof. Cobb's remark that it is necessary for the student "to bend his energies while his mind is young and elastic to saturating himself with the scientific principles of his industry." Even with the finest scientific education, the human mind is so imperfect that the day-to-day problems which arise require perhaps 90 per cent. acquired instinct and 10 per cent. scientific fact for their solution; and the saturation which Prof. Cobb speaks of undoubtedly helps a man to use this instinct to produce the best solution of such problems.

As one who has seen a great deal of the results of the research work which has been undertaken, I am perhaps particularly well placed to emphasize the value of this research work, especially in connection with the occasions when the gas industry has been criticized by an ill-informed public, or when legislation has been proposed in order to facilitate their operations. It is hardly necessary to enumerate the many occasions upon which accurate information has been forthcoming from the laboratory of the Leeds University which has rendered the labours of those responsible for arriving at a final decision much easier than it would otherwise have been. The work leading up to the Gas Regulation Act, 1920, and the Therm Inquiry which followed this a year or two later, the various carbon monoxide and inerts inquiries, and the work, recently completed, of the Area Gas Committee could not have been brought to a satisfactory conclusion without the research so modestly summarized in Prof. Cobb's report. I hope that the work, both teaching and research, of the gas industry and the Leeds University will continue to flourish and expand.

Work of a Fundamental Character.

Dr. F. S. SINNATT (H.M. Fuel Research Station, East Greenwich), in a written communication, stated: The subject of the technology of coal and its bye-products has assumed great importance technically, commercially, and politically; and research upon it is being prosecuted actively in many centres throughout the world. Only three universities in Great Britain—namely, London (where Prof. Bone is the Chief of the Department), Leeds (with Prof. Cobb), and Sheffield (with Prof. Wheeler)—have raised the science to the dignity of a full Chair. The work turned out by these departments is known as being of that fundamental character which is of such importance in the development of a technical subject.

The work of Prof. Cobb and his assistants is closely associated with the Institution of Gas Engineers; this close contact between the large-scale and the academic aspects of the

subject has contributed to its success, and accounts for the rapidity with which the results of the investigations are absorbed into the industry either directly or indirectly. Although research is of profound importance in the development of the work at a university, the most valuable finished product of the Department of Fuel is a young man trained and disciplined to scientific habits of thought and prepared to face the problems of the coal-gas industry with ardour and scientific efficiency. The close contact between the academic and the technical man enables these students to carry out researches which are of considerable use to the industry, and such work to the student may be considered as a valuable bye-product in his training. This work provides time and opportunity for the student to recognize the thousand-and-one problems which still remain to be solved in connection with the efficient carbonization and use of coal.

The success of the Fuel Department at Leeds, from its inception, shows that it is providing the type of man required in industry, and the responsible posts they have been able to fill indicate the high standard which is reached in the Department. The academic training they have received has been reinforced by knowledge acquired from contact with members of the Institution. It is of some importance to draw the attention of parents who are thinking of careers for their sons to the fact that men trained in the fuel departments in the country are readily absorbed into industry and are seldom without posts, and that during the last ten years there has been a continual shortage of men with scientific training in fuel. It is to be hoped that men who are interested in the coal gas industry will come forward and take advantage of the facilities offered them in the Fuel Department at Leeds University.

Mr. J. E. BLUNDELL (Carlisle), in a written communication, stated: Owing to lack of time I was unable to speak at the meeting of the Institution at which Prof. Cobb's important and interesting paper was under discussion.

The record of work done shows the great differences between the problems which confront the gas engineer or fuel technologist and those with which the mechanical or the electrical engineer has to deal. It is true that the electrical engineer does not know any more about the ultimate nature of the medium in which he works than the gas engineer's chemist, but the former has one immense advantage over the latter. His problems are generally capable of exact mathematical treatment. The limits of the efficiency of the transformation of heat into mechanical energy and again into electrical energy (and that is the whole problem of the electrical engineer on the manufacturing side) are fully known theoretically. They are laid down by the Second Law of Thermodynamics, and it is possible that the practical limits of efficiency, at any rate as regards present methods of electricity generation, are already reached in the modern power house. It is possible, of course, that the chemist will discover some more efficient means of transforming chemical into electrical energy without the necessity of passing through the mechanical phase at all. In the meantime, the fuel technologist is dealing with the problem, the factors of which are much less easily determined. They hardly ever lend themselves readily to mathematical treatment, or, indeed, to any exact treatment at all.

It is therefore not surprising that, in the comparatively short life of the electricity industry, its junior engineers have fairly easily been educated sufficiently to operate the plant at their disposal at the maximum efficiency of which it is capable. It is also to be noted that the efficiency of the highly developed machinery for the production of this class of energy, with a capital cost per unit somewhere in the region of four times that of the gas producing plant, is far less susceptible to the personal efficiency or inefficiency of its operators. There is therefore all the more reason why, if we are to keep our lead in the industry of the generation and distribution of energy, gas engineers must be brought within the influence of the university. That is so obvious that it would not warrant anyone's intervention in a discussion on Prof. Cobb's paper. What is not so obvious is that we cannot afford to wait until the industry is completely re-manned by young men who have all had the advantage of passing through the university. The university must go to the existing personnel. For that reason the question is being asked whether the Institution and the University working together have done all they should have done in the direction of providing educational facilities for the isolated student. In the meantime, the isolated student is himself taking advantage of such facilities as already exist for the acquisition of technical knowledge by correspondence. What one wishes to urge is that the Institution and the University cannot afford to let these facilities operate without their control and supervision.

THE ISOLATED STUDENT NEEDS HELP.

The latest development of the education scheme of the Institution has removed all restrictions upon the means adopted by students to obtain the necessary education to enable them to pass the several examinations, but no provision has yet been made by the Institution itself for providing educational facilities to such students. It is well known that such facilities have been made available by privately owned organizations and by private individuals, but, much as their enterprise is to be admired, it cannot be admitted that it is consistent with the dignity and prestige of the gas profession that this duty should be left in private hands. Nor can it be said that there is any guarantee that these organizations are staffed, or are likely to be staffed, by men of adequate status in gas engineering and fuel technology. The idea of obtaining education by correspondence appeals very strongly to a comparatively large number of men in junior positions, particularly those in the two classes, (*a*) of men who are too old to wish to attend technical schools, and (*b*) of men of all ages who are unable to get to technical schools and colleges. For these men the Correspondence College of University standing should be available. The idea of a Correspondence College of this status is not new. University Correspondence College of Burlington House, Cambridge, has been in existence since 1887, and is staffed by men of university standing. The prospectus shows that it is run on the lines of a college of repute, with a Principal, Council, and Staff whose names are given. Among these names are those of University lecturers and professors, and several of men well known in their particular departments, such as Messrs. Briggs, Bryan, Barlow, and Weekley.

My suggestion is that such a University Correspondence College should be run with the approval, and/or the assistance, of the Institution of Gas Engineers in connection with the Fuels Department of the Leeds University, staffed and organized to suit the special needs of students of gas engineering, and the requirements of the Institution's education scheme. The correspondence gas colleges and classes to which I have referred have done a great deal of good, and it might be possible and advisable for their organizations and staffs to be co-opted and incorporated in the new scheme. The very fact that they have a considerable clientele is proof of the existence of a real demand. My case is that the correspondence college for the gas engineering student should be the best which the united efforts of the Institution and the universities can put forward.

I trust that no mere prejudice will be allowed to stand in the way of a careful and unbiased consideration on the part of the Universities and the Institution of the claims of the correspondence college. Such prejudices are utterly out of touch with the keen spirit of the young men of the age.

My final point is that the Institution, having set up an education scheme which makes great demands on the isolated student, is in honour bound to see that facilities of the best kind are placed at his disposal.

The Preparation of a New Road Binder

By C. F. BROADHEAD, M.Inst.Gas E. (Melbourne).

Presented by HAROLD E. BLOOR, B.Sc., B.Eng., M Inst.Gas E.

It is almost ten years since the author (then Engineer to the Brisbane Gas Company) was confronted with a serious problem in connection with a change in the quality and subsequent disposal of tar. This problem was clearly connected with the abrupt alteration of carbonizing methods from hand-charged horizontal to continuous vertical retorts. The tar produced in the old horizontal retort system at Brisbane, on dehydration and removal of a very small percentage of the light oils, made exceedingly good and durable road material. Consequently, tar was a satisfactory and profitable bye-product. Not long after the starting up of the continuous vertical installation (which completely superseded the horizontals) it was realized that a change in the nature of the tar had rendered it almost useless as a road-making material when simply treated in the same manner as horizontal retort tar. The Brisbane City Council, which had taken practically the entire output of tar, gradually reduced its purchases, and, as the wells became full, tar had to be used and sold for fuel, as far as the limited demand existed, and the surplus was simply wasted.

In the meantime the Australian Gas Light Company of Sydney, having experienced similar difficulties, had resolutely set out to seek a solution of the problem. The work carried out in Sydney, though apparently little known in England, has been much appreciated in Australia. Naturally the writer discussed the Brisbane position with the officers of the Australian Gas Light Company, who made the suggestion that the most economical outlet might be found by utilizing the whole of the crude tar as a fuel. On it being pointed out, however, that Brisbane was most unfavourably placed geographically for the disposal of residuals, and particularly fuel oil, and that the writer still considered the most suitable market for the bulk of the tar was to be found in the local road-making requirements, it was recommended that the process of manufacturing suitable road-making tar should consist of :—

1. Dehydrating and distilling the crude tar to the state then practised in the existing stills.
2. Treating the product from (1) with steam in special stills to be provided, until a pitch of the required quality was obtained. The pitch to be then fluxed with suitable oils obtained from the crude oils previously removed in process (1).
3. The necessary fluxing oils to be recovered from the distillation of crude oils obtained from the process (1) in two new stills to be erected—the stills to be similar to those then in use.

This is in essence the principle of the "Duratar" process developed by the Australian Gas Light Company, which, however, the Brisbane Company did not see fit to adopt.

In 1925, the writer was appointed to the Metropolitan Gas Company, Melbourne, an undertaking that sold in the same year over 5 million gallons of tar, the principal purchasers being :—

	Gallons.
Municipalities	3,214,423
Distillers (2)	1,675,342
	4,889,765

the total revenue being £112,487, equal to 7d. per 1000 c.ft. of gas sold. This appears to have been the high-water mark in the history of the Metropolitan Company for the sale of this product, so that until 1925 the tar position appeared highly satisfactory.

The percentage amounts of gas produced in continuous vertical retorts during the previous five years were as under :—

1920	12·58
1921	23·09
1922	29·24
1923	33·97
1924	36·18

and during the past five years as follows :—

1925	51·53
1926	61·00
1927	51·87
1928	58·20
1929	64·72

Since 1925 the quantity of tar sold to large customers has shown a rapid decline as the figures below will indicate :—

—	1926.	1927.	1928.	1929.
	Gallons.	Gallons.	Gallons.	Gallons.
Municipalities	2,873,098	2,504,060	2,285,382	1,808,705
Distillers	1,407,372	1,454,278	1,167,460	1,203,839
Total	4,280,470	3,958,338	3,452,842	3,012,544
Revenue	£108,920	£70,552	£49,397	£41,885
Per 1000 c.ft. of gas sold	6·53d.	4·09d.	2·85d.	2·83d.

The quantities of tar used on the works for fuel during these years and in stock at the end of December were as follows :—

—	1926.	1927.	1928.	1929.
Used—gallons	..	139,000	1,316,610	1,522,591
Stock— ,,	685,081	1,762,512	1,766,791	1,423,728

During the past eight years the importation of bitumen increased enormously, as the following official figures will show :—

—	Victoria.		Commonwealth.	
	Gallons.	Value.	Gallons.	Value.
		£		£
1922	198,880	9,244	350,680	16,724
1923	1,104,774	29,355	2,369,884	63,680
1924	2,102,804	53,003	6,471,861	157,510
1925	1,757,624	46,735	5,033,842	135,613
1926	3,168,220	87,796	8,391,647	232,603
1927	6,546,474	158,854	16,837,579	404,408
1928	7,899,342	188,315	19,869,410	489,035
1929	8,077,091	148,067	20,191,336	408,271

There is no need to stress the relative tar and bitumen figures. It suffices to say that it has been realized for some years by those in Australia closely associated with the production, treatment, and use of tar that the quality of the product from continuous vertical retorts is inferior for road purposes to that produced by the older methods of carbonization. Observations show rapid deterioration of many roads treated with continuous vertical retort tar, suggesting that the cause of the trouble is undoubtedly in the nature of the tar itself. With the ever-increasing influx of bitumen, the superior life of which is unquestioned, the tar distiller is faced with the alternatives of changing the nature of the tar or risking extinction as a road material producer.

In 1927, the Metropolitan Gas Company sent the writer round the world for the purpose of gathering general information. Two matters requiring investigation were (1) the damage being done to meter leathers by some constituent of the gas, presumably from the continuous vertical retorts; and (2) the marked deterioration of the tar as a road-binder as the percentage of vertical retort gas increased. It was felt by the writer that some close association existed between these twin troubles.

In America it was ascertained that similar damage had been caused to meter diaphragms by the gum-forming compounds indene, styrene, &c., produced by the low-temperature cracking of oils in water gas carburettors. It is interesting to note, in passing, that a regular test is now carried out at Baltimore for indene and allied compounds. Continuous vertical retorts being comparatively few in the

United States the resultant road tar problem naturally had not appeared. In England there seemed little to be learned regarding the cause of excessive damage to meter leathers, but there was strong evidence that the trouble was well known to meter makers and others in the industry. So far as the tar situation in England was concerned it would not be possible to obtain a more comprehensive survey of the whole position at that time than the report of the Manchester Tar Conference (November, 1926). The actual returns for tar products derived from a ton of coal were given by one authority as 9s. 5d. and 7s. for vertical and horizontal retort tars respectively. Everything considered, it was stated, vertical retort tar has many advantages over other tars from a distiller's point of view, the total value of the derivatives being higher and refining both easier and cheaper, except in the case of the tar acids. The author, therefore, arrived at the conclusion, rightly or wrongly, that the distillates of vertical retort tar, being easily disposed of at a higher figure than those of horizontal retort tar, the preparation of road tar had become of secondary importance—at any rate for the time being. When this aspect was put to a leading distiller, he stated that 50 per cent. of the tar then produced was from vertical retorts, and that there was no difficulty in producing from the mixture a tar which complied with a standard specification, and was satisfactory to users of road-making material. The writer ventured the opinion that in addition to the difficulty of bringing within the limits of the specification the product of all tars—especially those from the low-temperature zone in vertical retorts—the product itself did not prove altogether satisfactory; also that no method of straight distillation would restore adhesive properties lost by a radical change in the constitution of the tar. It was distinctly disappointing to read the whole of such a valuable technical report as that of the 1926 Conference without finding any direct reference to this all-important phase. This feeling has been strengthened by the remarks of several surveyors and engineers attending the 1929 Road Tar Congress. The writer left England at the end of 1927 convinced that, should it become necessary at home to revert to the production of road tars to a greater degree, the position that had rapidly developed in Australia, owing to all the large cities installing vertical retorts, would sooner or later confront undertakings there. The following extracts from the 1929 "Gas World" Tar Review would seem to indicate that such a time has arrived :—

> In summarizing the outlook a year ago we found that the prospect of an early rise in tar prices was not hopeful. Subsequent events justified that somewhat pessimistic outlook, for in the first six months of 1929 tar yielded to its producers only half the return obtained for the corresponding period of 1928, and only three-quarters of the return for the six months ended Dec. 31, 1928.
>
> As a rough approximation to the course of prices, the interim payments per gallon in one co-operative scheme are here given, together with the corresponding figure per ton, taking 195 gallons as an average figure for horizontal tar :—

—	Interim Price.	
	Per Gallon.	Per Ton.
	d.	£ s. d.
1928.		
December	2	1 12 6
1929.		
January	2	1 12 6
February	1½	1 4 4½
March	1½	1 4 4½
April	1½	1 4 4½
May	1½	1 4 4½
June	1½	1 4 4½
July	1½	1 4 4½
August	1½	1 4 4½
September	1½	1 4 4½
October	2	1 12 6
November	2	1 12 6

The actual yields at final ascertainments of the same scheme in recent periods are as follows, the tonnage figure, as before, being calculated at 195 gallons per ton. The yield would be higher for vertical tar according to the divergence of its sp. gr. from the equivalent of 195 gallons :—

Six Months Ended—	Actual Yields.	
	Per Gallon.	Per Ton.
	d.	£ s. d.
31st December, 1927	4·897	3 19 6
30th June, 1928	3·805	3 1 9
31st December, 1928	2·934	2 7 8
30th June, 1929	2·095	11 4 0

Thus in the course of 18 months, a net yield has been reduced from 4·9d. to 2·1d. per gallon, or 57 per cent.

It is known that one-third of the total tar production is used in road work, or approximately 620,000 tons per annum. It is also known from Board of Trade returns that in 1927 the total quantity of bitumen imported was 260,640 tons, and that for the first ten months of 1929 the figure is 163,659 tons, at a declared value of £801,062. If the same ratio as for October is kept in November and December the imports of bitumen for the year will be 180,000 tons, of an approximate value of £900,000, an average of £5 per ton.

These figures will make interesting reading alongside the Australian figures previously quoted.

On the writer's return to Melbourne, he requested the Company's Chief Chemist to ascertain if the unsaturated hydrocarbons, indene, styrene, &c., were present in the gas produced in the continuous vertical installations. The answer being decidedly in the affirmative, we were then well on the track of our meter diaphragm troubles. While investigating various collateral problems we thought that as unsaturated hydrocarbons in the gas readily polymerize to gummy substances, it might be possible to polymerize to gums the higher boiling unsaturated hydrocarbons in the tar and thus render it more suitable for road purposes. The liquid hydrocarbons existing in the gas produced from continuous vertical retorts possess a higher percentage of unsaturated hydrocarbons than does gas produced from horizontal retorts.

The following table will suffice for a comparison :—

—	Light Oil (Gallons per Ton of Coal).	Unsaturated Hydrocarbons (Gallons per Ton of Coal).
Continuous vertical retorts, Maitland coal	3·88	0·72
Continuous vertical retorts, English coal	3·66	0·61
Horizontal retorts, Maitland coal	2·97	0·42

These unsaturated hydrocarbons polymerize to gums in the presence of oxygen. As far as can be ascertained, the initial reaction is one of oxidation to aldehydic and acidic compounds, which in the presence of oxygen act as catalysts in increasing the velocity of polymerization of the remainder.

It is natural to suppose that if the percentage of gum-forming constituents in the gas from the continuous vertical retorts is considerably greater than in the gas from horizontal retorts, similar conditions must prevail in their respective tars. After extensive examination this was found to be the case, and the table on the next page will show the difference in constitution between the two tars.

The chief unsaturated compounds existing in the tar that are readily polymerizable are :—

Compound.	Formula.	B.P.
		°C.
Styrene	C_8H_8	145
Indene	C_9H_8	182
Cumarone	C_8H_6O	169
p. methyl cumarone	C_9H_8O	197–199
m. ,, ,,	,,	195–196
o. ,, ,,	,,	190–191
o.p. dimethyl cumarone	$C_{10}H_{10}O$	221–222
m.p. ,, ,,	,,	221
o.m. ,, ,,	,,	216
Trimethyl cumarone	$C_{11}H_{12}O$	236
p. ethyl ,,	$C_{10}H_{10}O$	218
Methyl indene	$C_{10}H_{10}$	195–200
Dimethyl indene	$C_{11}H_{12}$	?
Indole	C_8H_7N	253
Acenaphthylene	$C_{12}H_8$	270
α naphthofuran	$C_{12}H_8O$	284
Fluorene	$C_{13}H_{10}$	295

While methods of straight distillation are quite satisfactory when applied to horizontal retort tar, they fail to yield an equivalent product from continuous vertical retort tar. Owing to the lower viscosity of the latter, it is necessary to remove more of the oils to obtain the same consistency as that of distilled horizontal retort tar, and, to do this, a higher temperature is required, and the brittle pitch content of the resultant road tar is increased. Coupled with this are the presence of waxes boiling between 280° to 300° C., and the higher unsaturated hydrocarbon content. These are three of the causes of the inferiority of continuous vertical retort tar for road purposes.

° C.	Continuous Vertical Retort Tar.				Horizontal Retort Tar.			
	Oil.	Paraffin Hydrocarbons.	Unsaturated Hydrocarbons.	Aromatic Hydrocarbons.	Oil.	Paraffin Hydrocarbons.	Unsaturated Hydrocarbons.	Aromatic Hydrocarbons.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
0–180	4·0	26	13	?	4·0	Trace	7·3	?
180–190	3·7	20	23	57	2·5	*Nil*	19·0	81·0
190–200	3·9	15	27	58	3·3	*Nil*	21·0	79·0
200–210	4·1	14	24	62	4·9	*Nil*	17·0	83·0
210–220	5·3	11	27	62	4·7	*Nil*	18·3	81·7
220–230	5·4	12	24	64	6·8	*Nil*	14·2	85·8
230–240	4·8	16	23	61	2·7	Trace	9·8	90·2
240–250	3·8	20	23	57	2·7	5·0	5·0	90·0
250–260	4·5	28	6·5	65·5	3·1	9·5	5·2	85·3
260–270	3·0	37	10·0	53·0	2·4	13·0	2·3	84·7
270–280	4·3	42	5·5	52·5	2·1	20·0	2·2	77·8
280–290	2·6	44	6·5	49·5	1·1	23·0	1·6	75·4
290–300	2·2	55	7·0	38·0	1·2	29·0	0·8	70·2
Pitch	48·4	..	..	..	58·4	..	..	..
Average	..	26	17	..	..	7·7	9·5	..

Some distillers have endeavoured to fractionate the tar and flux the pitch with the more suitable fractions. Although they succeeded in removing the waxes, they tended to accentuate the other two evils. Others again have endeavoured to overcome the deficiency by the addition of varying percentages of bitumen. This procedure, apart from conceding the indispensability of bitumen, is not a true compromise, as bitumen is composed mainly of asphaltic compounds which are extremely complex cyclic structures, while tar is a heterogeneous mixture of aromatic, hydrogenated aromatic, and chain paraffins both saturated and unsaturated, together with oxygenated compounds and bases. Some of the constituents of tar are not completely soluble in the constituents of bitumen, and *vice versa*, their immiscibility being accentuated as oxidation and polymerization proceed on the road.

The correct angle from which to approach the tar problem then would seem to be in the changing of the nature of the hydrocarbons themselves.

There are four common methods by which hydrocarbons may be changed :—

(*a*) Cracking.
(*b*) Hydrogenation.
(*c*) Oxidation.
(*d*) Polymerization and condensation.

(*a*) The probability of cracking tar as a method for improving it for road purposes does not commend itself, as its hydrocarbon architecture is such that cracking would deteriorate rather than improve the tar and impart to it a higher percentage of free carbon.

(*b*) Hydrogenation, apart from being difficult and dangerous, is economically impossible until the price of hydrogen is reduced to one-half of its present cost in blue water gas.

(*c*) Oxidation is comparatively simple and cheap, but results in a most peculiar material being produced. The material resulting from rapid and vigorous oxidation of some of the constituents of tar is of a fibrous and spongy nature in which the wax fractions are insoluble. When the product is handled after standing for a few days the oily waxes may be squeezed out leaving behind a fibrous "rotted" pitch devoid of ductility. Thus oxidation by itself is to be condemned, but partial oxidation in conjunction with polymerization and condensation produces a very satisfactory material.

(*d*) The property of polymerization, which is the coalescence of molecules to form higher boiling complexes, is possessed by most unsaturated compounds. It produces gummy, resinous bodies, which have all the inherent properties of good road binders, and therefore offer a ready avenue for exploitation.

Polymerization takes places very slowly unless accelerated by some catalytic agent, and oxidation products of unsaturated hydrocarbons form excellent catalysts. Investigations have found them to be aldehydic and acidic in nature and to accelerate greatly the velocity of polymerization. The nature of these oxidation products immediately suggests the addition of an aldehyde to the tar to commence polymerization, and this aldehyde would also form condensation products with the phenols and cresols of a resinous nature.

An endeavour has been made to produce aldehydic bodies *in situ* by addition of an oxidizing agent or the passing of ozone, but it failed to yield as superior a product as that produced by the initial addition of an aldehyde. Other aldehydes were then tried, but formaldehyde and acetaldehyde seemed to give the best results.

Procedure.	Yield.
	Per Cent.
(1) Straight distillation	61
(2) Passing of air at 170° C.	66
(3) Passing of ozonized air at 170° C.	79
(4) Addition of formalin and ammonia and passing of air at 170° C.	83·5
(5) Addition of formalin and ammonia and passing of ozonized air at 170° C.	84·7
(6) Addition of acetaldehyde and passing of air at 170° C.	80·0
(7) Addition of acetaldehyde and passing of ozonized air at 170° C.	83·2
(8) Addition of furfuraldehyde and passing of air at 170° C.	72·4
(9) Addition of furfuraldehyde and passing of ozonized air at 170° C.	79·8
(10) Addition of half quantity of formalin (0·5 per cent.) and passing of ozonized air at 170° C.	79·8
(11) Addition of formalin and copper catalyst in place of ammonia and passing of air at 170° C.	79·6
(12) Addition of hydrogen peroxide and passing of air at 170° C.	73·0
(13) Addition of copper sulphate and passing of air at 170° C. (material unsatisfactory)	77·1
(14) Addition of manganese dioxide and passing of air at 170° C. (material unsatisfactory)	70·1

Treatment in each case occupying six hours.

There seems little doubt that polymerization of unsaturated hydrocarbons played an important part in Nature's Laboratory in the formation of bitumen and asphalts. The ash remaining after the combustion of natural hydrocarbons frequently contains metallic oxides that would suggest catalysts to aid this polymerization.

Thus bitural—the name given to the new product—is an attempt to imitate Nature, and make tar as near as possible akin in properties to the superior petroleum product.

Bitural is prepared by intimately mixing 10 gallons of formalin and 5 gallons of 0·880 ammonia with 1000 gallons of tar, and digesting at 150° Fahr. for eight hours, when formaldehyde condensation products are formed *in situ* with the phenols, cresols, xylols, &c. At the termination of this period heated air is either passed through or over the tar, until the desired consistency is reached, when the unsaturated hydrocarbons, in the presence of formaldehyde oxidation and condensation products and in the presence of air, are converted to gummy polymers. Dur-

ing this stage the temperature is gradually raised to 380° Fahr. If it is decided to pass the air through the tar then the temperature is kept lower as oxidation would otherwise be carried too far, and the " rotted " pitch previously mentioned would be produced. Unfortunately, the process is not as rapid as is distillation, but, owing to the low working temperature, the cost of plant is considerably less, and, the operation being almost automatic, the labour cost per gallon is less. The output per unit of capital invested is greater.

The finished product can be made to any consistency desired, but it has been found more satisfactory to produce a material of 220 penetration resembling the softer grades of bitumen.

Penetration at 77° Fahr.	220
Ductility at 77° Fahr.	89 cms.
,, ,, 32° Fahr.	0·4 cm.
Free carbon	9 per cent.
Melting point	106° Fahr.
Oils distilling to 300° C.	12 per cent.
Sp. gr. at 60° Fahr.	1·16

When the product is distilled to 300° C. the residual pitch possesses a ductility of 45 cms. at 77° Fahr. as against zero for ordinary pitch. The reason for this is the large quantity of gummy substances present which flux the residual pitch and make it plastic, and in this property lies the advantage of bitural over distilled tar. This may be seen more clearly in the comparative penetrations before and after a weathering test of bitumen, bitural, and distilled tar.

—	Bitumen Penetration. 200.	Bitural Penetration. 220.	Distilled Tar Penetration. 227.
Before test	200	220	227
After test	200	137	35

The claims made for this chemically prepared product, in comparison with distilled tar, are as follows :

(*a*) The unsaturated hydrocarbons are polymerized under control before the tar is placed on the road.
(*b*) The tar acids which aid polymerization are " fixed " by formaldehyde condensation.
(*c*) When the oils eventually evaporate a plastic material remains behind on the road and not a brittle, friable pitch.
(*d*) The presence of plastic gummy substances instead of oils decreases the vapour pressure of the material thus retarding the evaporation of the oils present.

These four factors combine so to improve the nature of the tar that the longevity of the road is increased to such a degree that it is confidently expected that tar will be restored to its old status in road construction.

Naturally it will be asked—What practical progress has this process made?

Early in 1929 a pilot plant capable of producing approximately 125,000 gallons of bitural per annum was erected by the Metropolitan Gas Company at its West Melbourne Works. Up to the end of 1929 about 25,000 gallons—equivalent to 125 tons—had been sold in small lots to various users for experimental purposes including the Victorian Country Roads Board, the Melbourne City Council, and twelve suburban local authorities. For the first quarter of 1930 the plant has worked at full capacity, over 40,000 gallons (200 tons) having been disposed of, while orders have been received for more than double that amount. Arrangements are being made to increase the capacity of the plant at West Melbourne to half-a-million gallons per annum. The Country Roads Board of Victoria has experimented extensively with the material, constructing roads at all periods of the year, including the winter (which is not severe in Victoria), and have used it for various purposes in road construction, including water-bound macadam roads primed with a priming tar and sealed with bitural. In this connection it may be interesting to note that the priming tar used is collected separately at the condensers and dehydrated centrifugally to a water content lower than 1·5 per cent. This product contains about 60 per cent. of pitch, which is quite plastic at 77° Fahr., and 4 per cent. free carbon, and has an Engler viscosity of 7·5. Almost half-a-million gallons of this intermediate grade have been sold by the Metropolitan Gas Company to the Country Roads Board during the past year.

The Country Roads Board, twelve months ago, constructed 220 yards test lengths of road on the main interstate highway as follows :

1. Bitural penetration and bitumen seal.
2. Bitumen penetration and bitural seal.
3. Bitural penetration and bitural seal.

Their procedure is to heat the material to 225° Fahr. and apply 1·3 gallons to the yard for penetration and 0·33 gallon for sealing. This road shows no sign of deterioration on any test lengths.

Bitural has been used by local councils for :

1. New road construction.
2. Penetration and sealing scarified old roads.
3. Top dressing old roads.
4. Top dressing water-bound macadam roads.
5. Top dressing wood blocks.

At the West Melbourne Works a test strip has been laid down in the yard near the coke bunkers, from which about 400 tons of coke are taken daily. This strip after twelve months of grinding wear by heavy traffic of all descriptions is still in good condition. But probably the most interesting test performed was the top dressing, during frosty weather, of the concrete road to the water gas plant. Tractor traffic conveying about 50 tons of coke per day passes over this road, and at the end of twelve months, with a variation in the ground temperatures from 23° to 140° Fahr., no deterioration can be observed.

It is, of course, too early to predict the actual length of life of the new material compared with high grade bitumen when used for various road-making purposes. The product has met with a most encouraging reception, however, even in quarters previously definitely hostile to distilled tar. One municipal engineer who had not used a gallon of tar for five years, and who expressed the firm intention of continuing that policy, was persuaded to give bitural a trial. The result was an order quite impossible to fulfil at present. The Colonial Gas Association, having erected a plant in Melbourne capable of making about 250,000 gallons of the product per annum, more extensive trials will be possible.

The experimental plant at West Melbourne Works, on which the greater part of the research work has been carried out, is really a small-scale manufacturing plant having a capacity of 125,000 gallons per annum.

It consists of two welded-steel digestors, each 8 ft. diameter by 5 ft. 10 in. deep, with dished bottoms, and contained in brickwork settings. Heating was first carried out by gas burners below the digestors, but this was changed to heating by steam coils within the digestors. The gas burners were retained to supply the extra temperature required at the later stages of the process.

Compressed air was first bubbled through the tar, but this was abandoned in favour of drawing the polymerizing air over the surface.

The polymerizing air is drawn in through the covers of the digestors and passes across the product, taking with it the oil vapours to the outlet and thence into the coolers consisting of five lines of 3-in. wrought-iron pipes about 18 ft. 6 in. long, arranged to give a continuous maximum travel of 100 ft. These pipes are cooled by means of a water spray and air.

A small motor-driven exhauster draws the polymerizing air through the plant discharging to the atmosphere after the oils have been deposited. These are stored in a tank at the end of the coolers. The finished product is discharged into a steam-heated storage kettle on the ground. This kettle is equipped with a geared pump inside for filling an overhead service tank, which is also equipped with a steam heating coil.

The cost of treatment in Australia, with a plant of this size, appears to be about 2d. per gallon, including formalin at 6s. 6d. per gallon, ammonia at 5d. per lb., labour at £1 per shift, and interest and depreciation at 0·33d. per gallon. As the capital cost of the plant and manufacturing cost (not to mention the cost of living) seem to be about double those prevailing in England, costs at home should be about half of those here.

The leading firm of tar distillers in New Zealand, whose engineer and chemist have spent some little time in Australia making investigations, have signified their intention of adopting the process. It is interesting to note

that the New Zealand people propose to adopt electrical heating in their plant.

A contract has been entered into by a large tar distilling firm in Melbourne for the first unit of a plant with an ultimate capacity of 1 million gallons per annum, the eventual total cost being little short of £10,000. An estimate of the financial position is given below :

Standard bitural plant consisting of four digestors, each of 2500 gallons capacity with all accessory plant—at a total capital cost of £10,000. Capacity is assumed at one million gallons of tar treated in 280 days, and at 2½ charges in 7 days per digestor. Four digestors = 400 charges.

Tar	=	3d. per gall.
Formalin	=	6s. 6d. per gall.
Ammonia	=	3s. 4½d. per gall.
Labour	=	£1 per day
Current	=	1½d. per K.V.A.
Fuel	=	3d. per gall.
Oil and sundries	=	10s. per week

The tar is considered to have a 2 per cent. water content, therefore the amount of tar available for manufacture = 980,000 gallons. Of this amount 80 per cent., or 784,000 gallons, represents bitural, and 20 per cent., or 196,000 gallons, represents oil.

DEBIT.	£	CREDIT.	£
Depreciation—Provide sinking fund to extinguish capital cost in 15 years at 5 per cent. = 4·634 per cent. = say	465	784,000 gallons of bitural at 6d.	= 19,600
Repairs = say	300	196,000 gallons of oil at 4d.	= 3,266
Materials—		Total sales value	= £22,866
Tar, 1,000,000 galls.	12,500		
Ammonia, 5000 ,,	845		
Formalin, 10,000 ,,	3,250		
Fuel, 81,200 ,,	1,015		
Electric current	630		
Oil and sundries	20		
Labour	840		
	£19,865		
Balance	£3,001		

It will be noticed that the plant is considered to be working for only 77 per cent. of the year.

The design of the first plant for the manufacture of bitural on a commercial scale occupied a great deal of attention, as it was necessary first to co-ordinate the data obtained from the experimental plant to the requirements of large scale working operations, and then to establish the fundamental data on which future designs would be based. Important features were those of capital cost and manufacturing expenses, and to meet the first requirement it was decided that the plant should be of unit construction capable of expansion, unit by unit, to predetermined maximum outputs. The second requirement demanded that the manufacturing process should be more or less automatic in its action, requiring the absolute minimum of attention with the maximum safeguarding of the operations.

These considerations finally resolved the design into two standard digestor units of 2500 and 5000 gallons capacity respectively, and so arranged that four units would be the maximum in any one plant. The digestor units would be ranged round a central control structure, giving a ground plan in the shape of a Greek cross. This permits of one unit being constructed at a time, allowing the plant to grow with the demand. It enables succeeding units to be constructed and connected into the units working, without any interference.

The central control structure is common to all four digestor units and requires to be completely erected with the first digestor unit. It has three floors, the top containing the ammonia, formalin, and oil storage tanks, together with the blowers supplying the polymerizing air, and cyclone oil extractors, &c., the second containing the digestor furnaces and controls, while the bottom floor contains the kettle furnaces and the blowers for air supply to the furnaces.

Consideration of the economical arrangement of the accessory plant contained within the control structure indicated that the ammonia and formalin storage tanks, with their associated measuring tanks and pumps, should be common to all four digestor units. Similar considerations dictated the apportioning of two digestors to each blower supplying the polymerizing air, with its cyclone oil extractor. Two fuel oil storage tanks are arranged so that each will serve the furnaces of two digestors and two kettles. Each digestor unit is carried on its own two-storey structure, the upper floor carrying the digestor and the lower the storage kettle. Above each digestor is its associated heat exchanger and condenser, together with its share of the connections to the plant in the control structure.

It will be seen, therefore, that the plant is arranged for gravity flow, all materials flowing to the digestor, which in turn discharges directly into the kettle below. The kettle itself is placed at such a height as to permit the delivery pipe to feed either tank wagons or drums, and in such a position that any fumes discharge directly into the open air without discommoding the men engaged in filling operations or working on the plant. The delivery valve from the kettle is actuated from the ground, rendering it unnecessary for anyone not engaged on the plant to enter the structure.

This plant is actually under construction at the tar distilling works of the Albion Quarrying Company Pty., Ltd., in Melbourne.

DIGESTOR.

The 2500-gallon digestor is 11 ft. square by 4 ft. 6 in. deep, and is constructed out of ¼-in. steel bottom plates and ⅜-in. steel sides and top plates. Following the Metropolitan Gas Company's standard practice, the digestor and the whole of the steelwork in the structure and the rest of the plant are electrically welded using Quasi-Arc electrodes. The only bolts in the structure are those securing blank flanges and manhole covers. The general design is, therefore, simplified, and generally lighter sections and materials can be used and with greater rigidity than is found in riveted construction. The digestor is welded with Quasi-Arc special boiler electrodes as there will be considerable fluctuations of temperature during the process, and this type of electrode gives a weld of great ductility. The steel plates are welded directly to each other without the use of corner angles, and the top, bottom, and sides have stiffeners welded in.

Digestor Heating Arrangements.—Heating is accomplished by an external furnace fitted with an oil burner, the hot gases being conducted into a distributing flue and thence into 6-in. steel tubes which extend across the digestor, and terminate in 12-in. diameter steel headers, from which the gases return through six similar tubes to the waste-heat collecting flues. These flues are fitted one on each side of the furnace, and three of the return tubes discharge into each flue. To prevent local heating at the points where the 6-in. tubes join the distributing flues, a portion of the waste gases is re-circulated, by means of a Venturi tube and blast pipe in each of the waste-heat flues, back into the furnace, being admitted through ports at the end of the oil burner flame in such a manner as to produce a turbulent effect to temper the heat of the flame to the desired degree. Slides on the outlet vents on each of the waste-heat flues balance one against the other.

Furnace Heat Controllers.—The oil burner is controlled by a Foxboro' time temperature recording heat controller, actuated from a bulb set in the body of the heated product in the digestor. The controller operates on the oil supply line, opening or closing a spring-controlled diaphragm valve as the temperature tends to fall or rise. A by-pass allows a small continuous flow of oil to come forward to the burner to maintain the flame when the diaphragm valve is closed. Regulation of the heating cycles is obtained by the insertion of an appropriate cam on the spindle of the controller, and as the controller will be housed in a padlocked steel case with plate-glass front there can be no interference with the working of the furnaces. With the first plant the proposed cycle for each batch of bitural will be to raise the tar from its initial temperature of about 66° to 200° Fahr. gradually over a period of ten hours, and then relatively faster to 400° Fahr., where it will be steadily maintained until the process is complete.

Considerations Governing the Adoption of Oil-Fired Furnaces.—When the heating arrangements of the digestors and kettles were considered, steam appeared to be the obvious agent until it was found that a pressure of 250 lbs. per sq. in. was necessary to maintain the product at 400° Fahr. in the vessels. A power plant supplying this pressure is not readily available, especially in the situations where a bitural plant would be erected. Considerations of capital cost ruled the provision of a separate boiler plant right out of the question, as did the working expenses with a certificated boiler attendant in each shift. Again, the provision of steam supply mains to the digestors and kettles together with the heating coils, at this pressure,

requires very high-class workmanship and materials, so that, on all counts, steam heating proved too costly for the purpose. On the other hand, oil-burning furnaces appeared to be ideal; they could be made integral parts of the digestors and kettles, ensuring no heat losses between them and the heating flues, while their design was simple and cheap in construction. The fuel supply was ready at hand, as the residual oils recovered from the process were estimated to be more than sufficient for the purpose. The burners, however, would not be limited to this class of fuel, as, should the residual oils have a greater sales value than a heating value, crude oil or tar could be used instead.

The use of oil for heating allowed a change to be made in the design of the digestors, and, instead of the circular form generally used with steam coils, a rectangular vessel was adopted. This allowed a straight-forward layout of the heating flues, which are all straight pipes, and, in addition, gives a better distribution of the polymerizing air. The supporting structure is simplified and rendered more compact.

Polymerizing Air Duct.—The polymerizing air is admitted through the top plate into two ducts—one on each side of the digestor. Each duct is a double compartment; the first, into which the air is admitted, tapers towards the opposite end, the air increasing in velocity on its way. At the end of this duct the air returns again in a similar duct, which, however, has its outer wall tilted and pierced with a number of holes through which the air escapes, at a relatively high velocity, passing over the surface of the product to a centre duct, which it enters through holes in the two walls, finally passing away through the outlet as heated oil vapours. The bottoms of all the ducts are open, the side walls being sealed in the product so that the polymerizing air is brought into intimate contact with every square inch of surface of the product.

Digestor Fittings.—The digestor is equipped with a 3-in. tar supply on the side, together with ¾-in. formalin and ammonia supply pipes on the cover. A 2-in. plug cock is fitted on the cover close to the front for gauging the depth in the digestor and for returning tar drippings from the ¾-in. plug cock depth indicator on the side. A sampling cock is fitted midway down in the front of the digestor; this consists of ¾-in. plug cock with a pipe extending into the digestor with a funnel in the end. The heat controller is fitted in a case at the front of the digestor, and accommodated in this case are two 5-in. dial thermometers, one for indicating the temperature of the outgoing oil vapours, while the other indicates the temperature of the bitural in the storage kettle below. Two manholes in the cover give access to the digestor.

The outlet plug cocks that are usually found on tar plants have been discarded. This type of cock freezes after it has been closed off, and has to be heated with a blow-lamp or a torch of oily waste before it can be opened—a potentially dangerous procedure. Instead, an outlet sump has been fitted to the bottom of the digestor with a screw-down plug actuated by a spindle passing up through the cover. There is no chance of this plug valve freezing until the contents of the digestor cool down and solidify.

Insulation.—The digestor is placed on a cork board mat 1 in. thick, and the sides and top are covered with a 2-in. thickness of magnesia and asbestos lagging reinforced by wire netting.

Anti-priming Valves.—Every care has been exercised to render the plant safe against all contingencies, and to make it as fool-proof as possible. With this in view, consideration has been given to the possibility of priming, which, while it may be extremely rare on this plant, still remains a possibility. This contingency is dealt with as follows:—

The polymerizing air supply to the heat exchanger is brought from near ground level through a 12-in. diameter steel pipe which has its lower end guarded by a splash pot. Near the top of one side of the digestor a rectangular connection extends to this 12-in. pipe and is normally kept closed by a safety release shutter, which remains in the vertical shut position until there is a pressure rise of four-tenths of an inch water gauge in the digestor, when it overbalances, positively, and falls flat, leaving a free opening to the ground. The other passages between the digestor and heat exchanger each contain a similar counter-weighted shutter, which is normally held in the open position by a locking bar extending across to, and held by, the safety release shutter, already referred to. This, in falling, kicks the locking bar out of position, thus releasing the counter-weighted shutters, which close at once. Thus frothing is kept out of the rest of the plant, and the froth is given a free passage to the ground, where it escapes through the splash pot in a direction where it can do no harm or cause any hazard.

Heat Exchanger.—The heat exchanger is placed directly above the digestor, but supported in its own structure. The outgoing hot oil vapours from the digestor pass around 336 2½-in. outside diameter tubes 6 ft. long, being baffled to give the longest travel possible. The incoming polymerizing air supply passes through the heated tubes in a to and fro direction, and finally enters the digestor through the air ducts. The raising of the temperature of this incoming air should materially lessen the digestor furnace fuel bill, and, in addition, should help to shorten the time for each batch, as there is some relation, yet to be determined, between the polymerizing air temperature and the time of manufacture. The heat exchanger is lagged in order that the outgoing heat is utilized to the full. What oil is deposited here will be taken to a central seal pot.

Condensers.—From the heat exchanger the oil vapours pass directly to the condensers which consist of two 12-in. diameter vertical steel headers with ten 4-in. diameter by 10 ft. 6 in. long steel pipes set between. The vapours pass along five of these pipes returning through the remainder. The condenser is arranged for water cooling by external sprays. The residual oils are collected and taken to the central oil seal pot.

Blower and Cyclone Oil Extractor.—From the condensers the vapours are drawn into the centrifugal blower of 2100 c.ft. per minute capacity at 16-in. water gauge and directly coupled to a 12½-H.P. A.C. motor. The discharge passes into a cyclone oil extractor of the usual form, but provided with an internal spiral. Both blower and cyclone are connected to the central oil seal pot to drain off any residual oils that may be left. From the cyclone the oil freed air is discharged into the atmosphere above the roof.

Storage Tanks.—The formalin and ammonia storage tanks are each of 169 gallons capacity, and are fitted with measuring tanks of 25 gallons and 12½ gallons capacity respectively. A special duplex plug valve has been evolved to prevent the whole of the contents of either storage tank being discharged through the measuring tank into the digestor. The measuring tanks are fitted with a special compensating device to determine the exact volume for any one charge. These tanks are filled from 1-in. centrifugal pumps located on the ground, and are fitted with the usual inlet and outlet connections and indicating devices.

The oil tanks have a capacity of 800 gallons, and have a ball float chamber incorporated in their base to maintain a constant head of oil to the burners. Oil is delivered by pumping, and an Autokleen strainer is fitted to the outlet. A float, with indicator, is fitted, the indicating scale being fixed to one of the columns near the ground level.

STORAGE KETTLE.

The storage kettle is placed below the digestor, and is of the same construction and dimensions, and has similar heating flues. The furnace is smaller as its function is to maintain the hot charge from the digestor at a temperature suitable for discharging into the road tanks. It does not, therefore, require re-circulation of the waste gases or a heat controller. Its only fittings are a capacity indicator, inlet connection from the digestor, outlet valve, and swinging filling pipe. A vent is provided to admit or expel air during the emptying and filling of the kettle. The insulation follows that of the digestor.

Electrical Equipment.—For safe working the blowers for the polymerizing air supply and the blowers for the air supply to the furnace burners are interlocked, so that in the event of the main blowers stopping for any reason, the furnace blowers are cut out at once, and a solenoid is arranged to cut off the oil supply and cause a Klaxon horn to sound. This is a further safeguard to that provided by the heat controller, so that, generally, the plant is protected at all points.

The general arrangement of the plant, with the safe-working devices provided, should permit it to run unat-

tended except on the morning shift, when a man would be required to discharge and charge the digestors, replenish the storage tanks, lubricate the blowers and motors, and keep the plant clean.

It will be obvious that the preparation of a new product such as described in this paper necessitated a co-operative effort, and the Author wishes specially to acknowledge his indebtedness to the Chief Chemist of the Company (Mr. R. S. Andrews, B.Sc.) for his research work in the laboratory; also to Mr. H. E. Grove, the Company's Construction Superintendent, for his personal interest in the design of the plant, and to Mr. L. F. Loder, Chief Engineer to the Victorian Country Roads Board, for his encouragement and assistance.

Mr. BLOOR, presenting the paper, referred to one or two contentious points. He summarizes his remarks as follows: I stand before you to-day in a somewhat peculiar capacity. I am presenting a paper to you which is not of my own production, but that of my friend, Mr. C. F. Broadhead, of Melbourne.

Perhaps I might be allowed to say on such an occasion that years ago, in our comparative youth, Mr. Broadhead and I met as friendly competitors for a position in the Gas Engineering world, and that we have remained friends, though at a long distance, ever since, and he has done me the honour of asking me to present his paper to you to-day.

I wish to make it perfectly clear that I am merely in the position of a friend of the author putting the paper before you for your criticism, and my responsibilities will be completed when I have informed Mr. Broadhead of my opinion as to the reception of this paper, and drawn his attention to any points arising in the discussion, or arising out of the paper, of which I think he ought to be informed.

My position is to some extent a difficult one, unless that position is fully appreciated by you, and by all who are interested in this paper. It happens that I am a Member of the Council of the British Road Tar Association, and also the Vice-Chairman of the Yorkshire Tar Board. In both of these capacities I have a vital interest in the value and repute of British tar as a road material, and the paper takes for granted many things which are entirely opposed to English experience and to my own views.

It is apparent throughout that the conditions which caused Mr. Broadhead and his collaborators to set about the production of bitural are definitely Australian conditions, and do not apply to this country.

The coals carbonized are Australian coals, and it is especially to be noted that the individual gas companies are the distillers in Australia, whereas for the most part in this country we are concerned with a distilling industry which deals with a blended product consisting of horizontal and vertical gas-works tar and coke oven tar, and which is in the habit, in so far as it is producing road tars, of treating and blending these crude tars in such a way as to produce an ideally constituted road tar for road-making material. It will be noted in the paper that the percentage of vertical retort tar in the two five-year periods for which Mr. Broadhead gives particulars shoots straight up from 36 to 51 p.ct., and goes up as high as 64 p.ct.

I have said enough to indicate that the entire conditions dealt with by Mr. Broadhead in Australia are Australian, and that care and discrimination must be exercised in applying to English conditions conclusions or methods which Mr. Broadhead appears to have found satisfactory in the Antipodes.

I now submit the paper for your consideration, and hope that there will be a long and valuable discussion, because we are all vitally interested in the question of the use of British produced materials for British roads, and I hope that Mr. Broadhead's work will be found to have a value even to us on this side of the world. I see no reason why it should not do so if we have regard to the different conditions to which I have already referred.

DISCUSSION.

The PRESIDENT: We have been told in the paper about the apparent inferior quality of vertical retort tar for use as a road binder. The author was faced with this situation in Australia, and has told us his remedy. He must be congratulated on developing a process which has enabled him to compete successfully with bitumen. A proper financial return for tar is a very important factor in the economics of gas manufacture, and we must ask ourselves the question, "What is the position of tar for road-making in this country to-day?" Is it influenced by the increasing proportions of tar from continuous vertical retorts? It will be indicated in a paper to be given later that considerably more than 60 p.ct. of the tar produced by the gas industry is from continuous verticals. We have nearly 180,000 miles of road in Great Britain, we have the very active British Road Tar Association, and we have the co-operation of the tar distillers themselves. Our position ought to be a strong one, and yet the value of bitumen imported into this country in 1929 was over £3800,000. A connection has been indicated between the products of carbonization from vertical retorts and damage to meter leathers. In this connection it is interesting to note that at a later meeting a paper will be given on benzole, in which methods of arresting polymerization are indicated. If liquids can be treated successfully, why not gases?

The paper by Mr. Broadhead is full of interesting topics, and opens up a field for an active discussion. I hope you will give your experiences and considered opinions.

Mr. H. E. COPP (Vice-President): I think Mr. Broadhead is to be congratulated on having produced a very interesting paper. It is interesting from two points of view. In the first place, it shows that there are difficulties experienced in the treatment of vertical retort tar; and, secondly, it puts forward an original method of overcoming those difficulties. But I should not like it to go out from this meeting that, because a vertical retort tar does not fill the bill in Australia, it cannot be made to do so in England, because I claim that it is possible to produce a most excellent road tar from vertical retort tar. I should also like to say that there are many statements in this paper to which I do not subscribe. The absence of any attempt to differentiate and to explain the difference between the climatic conditions in this country and Australia represents a grave omission. He attributes the fall in the prices of tar in this country largely to the alleged inferiority of vertical tar, but that is not the reason. The fall in prices is due principally to heavy production, German competition in a free market, and reduced creosote exports to America. I have figures which tell a rather sorry story of the fall in the value of tar during the past ten years. Whereas in the half-year ended December, 1920, the value of tar was 9·15d., in December, 1929, it had fallen to 2·754d. This indicates that we have to use our wits in order to produce the tar required. My own opinion is that what is principally the trouble in respect of vertical retort tar in this country is the specification. Why on earth the specification has been fixed as it is I do not know. You have to produce a tar of very high viscosity in order to obtain the best specific gravity, but I maintain that high specific gravity has very little to do with it, and that in many cases a low specific gravity is of decided advantage. The author has condemned root and branch the cracking of tar in order to make it suitable for roads. There again I cannot agree with him. It is stated that horizontal retort tar is generally preferable for the preparation of a road binder, and I would point out that the very reason why it is preferable is that it is subjected to a certain amount of cracking in the course of its production. I submit that one of the principal solutions of the difficulties that arise may be in deliberate cracking of the tar. This can be done easily by waste heat in vertical retorts; there is plenty of waste heat available for the purpose, and it might easily be done in closed chambers which might be reversed in the same way that regenerators are reversed in a coke oven setting. As to costs, the author has said that in this country the costs of treatment for the production of "Bitural" might reasonably be reduced to about half the costs of the treatment in Australia. It would be impossible to incur that cost in this country, however, because that cost of treatment would represent an addition of 25 or 30 p.ct. on the existing price of tar; if we went to the surveyors and said we had produced a special tar, but wanted them to pay an extra 25 p.ct. for it, I think their answer would be disappointing, to say the least. We have made laboratory experiments on tar which was exclusively vertical tar, and have found that by distillation with formaldehyde in the manner described in the paper we cannot produce a tar which will comply with the specification. If you get a viscosity as high as 100 per second the specific gravity is only 1·18, and then you cannot comply with the specification. I should like to hear it explained that there are ways and means by which vertical tar can be treated and made absolutely suitable for road purposes, while complying with the specification.

Col. W. M. CARR (Stretford): I am very greatly interested in the work that has been done in Australia in the matter of polymerization of vertical retort tar as distinct from straight distillation. It would have been interesting if Mr. Broadhead had told us more fully how they were carrying out their straight distillation when their difficulties first arose. He does not say whether they had tried refluxing as a method of increasing the viscosity. There is no doubt that most tars will yield to treatment, and it is admitted that tars even from the same form of carbonizing plant, but from different coals, require very different treatments in order to produce road tars to meet the same specification. Therefore, it is possible—and I think it is indicated directly in the paper—that a great deal of the trouble that has been experienced in Australia, and which we have not experienced in this country, is due entirely to the nature of the coals, and possibly also, as mentioned by Mr. Copp, to the atmospheric conditions which prevail there and which do not apply here.

I should like to refer to the comparison that is made of the

values of tar in this country, because I think that the price of road tar has been not only maintained in relation to the commercial price of bitumen, but in the past three years has been relatively improved, and with the co-operative schemes which are in operation we have been able to secure tars, over large areas and in large quantities, to produce mixtures, and to produce a standard product which is appreciated by the surveyors of the country. I rather think that this paper should serve as an indication that we in this country are not falling behind, but that we are advancing. We cannot admit that road tar to-day is inferior to the road tar of five years ago; on the contrary, we know that it has very much improved, and that to-day, by reason of our co-operation, we are able to put on the market an article which is standardized which we can guarantee as standardized, and which we can guarantee will carry out the work as well as any natural bitumen product that is marketed.

Like Mr. Bloor, I am not quite sure what is involved in the weathering test referred to by the author, but the figures seem to indicate that as the result of a weathering test there is no deterioration of the natural bitumen product, whereas there is a very large deterioration, so far as penetration is concerned, of the distilled tar. It is very difficult to accept these figures without explanation, because we do know, and we have been told by our friends the road makers, that the deterioration and the loss of electricity—I am not quite sure that this is the right word—in a bitumen material due to weathering is very much greater than that in a prepared road tar.

Finally, I think we do appreciate Mr. Broadhead's interesting description of his plant, and there is no doubt that in some instances, and with special coals, it will repay very careful investigation even on our part.

Mr. H. D. MADDEN (Cardiff, Past-President of the Institution): I should like to express my entire agreement with the criticisms of the paper made by Mr. Bloor and Mr. Copp, but, at the same time, I would not like to detract from the value of the paper, which has drawn very close attention to the tar question in this country. I agree with Col. Carr that the value of tar for road-making has improved very much during the past five years, and, furthermore, I would stress very strongly the fact that vertical tar is eminently suitable for road-making if properly made up. I have thought over this paper and have made some examinations before attending this meeting. My mind went back to an occasion, more than 25 years ago, when we had a cargo of Australian shale at the Kensal Green Works of the Gas Light and Coke Company, and the remarkable thing about that material was that one could light it with a match. It seems that the trouble that Mr. Broadhead has to meet is divided into two parts. In the first place, the trouble is not in his vertical retort, but in the coal, which is entirely different from the English coals; and secondly, there is trouble due to climatic conditions. However, I think there will be found some means of overcoming the difficulties.

With regard to the gummy deposit in meters, the author attributes that to the vertical gas; but I am not satisfied that that is so in English practice. If there is a gummy deposit on a meter, and that deposit is dry when you open the meter, to my mind the deposit is due to the presence of oxygen, which has been drawn into the dry mains, giving them a higher oxygen content than they would have if great care were taken to ensure that the inerts were reduced to a minimum. At my works we have experience of some 4000 meters per annum, and have examined a good many hundreds during the last few weeks, in order to find out whether these gummy deposits do occur—we are using very largely vertical retort gas—and we find that the meters have a slight oily deposit, which might be due to the condensation of hydrocarbons of the coal gas or water gas. The deposit does not get sticky until it has been open to the air for about 24 hours. I think that is a point concerning the oxygen content of the gas which might be examined.

We look forward to coming into our own again in the matter of the use of tar for road-making; and in this connection I should like to refer to the valuable set of papers by Mr. Salkield (the late City Engineer at Delhi), in which he has drawn attention to the use of British tars for road-making in order to reduce vibration and noise resulting from the passage of heavy traffic. I am inclined to think that in tar we have a material which is better than bitumen for road-making, in reducing these two nuisances. Finally, I do not think we have paid sufficient attention to the critical point, which is viscosity, in producing tar for road-making purposes. I think that if we give this matter a great deal more attention than we have done, we shall find a critical viscosity which will not involve interference with the specific gravity demanded by the specification.

Dr. E. W. SMITH, C.B.E.: I have been fortunate in that Mr. Broadhead sent me, in advance, information regarding his process, and asked that if it were applicable in this country, and after a certain amount of work had been done on the subject, it should be made available through my Company for this country. In looking into the bitural process one is impressed by the fact that it does not in any way attempt to produce tar which will conform with the British Road Board's specification. It is a means of producing an artificial bitumen. In so far as it is advisable to use bitumen at all, then it is possible to produce from Australian vertical retort tar an artificial bitumen. Whether or not the process would pay or would be applicable in this country is another question, and before we can answer the question a considerable amount of work will have to be done, not on one but on many continuous vertical retort tar samples from different parts of the country, from typical coals. Australian coals give vertical retort tars which are very different from any tars produced in this country. But as 75 per cent. of the tar made by carbonization in this country is continuous vertical retort tar, it is a subject which must be given very serious consideration. There is a real problem in dealing with continuous vertical retort tar for road purposes. There have been many difficulties, particularly in those districts where there is not the possibility of sending the tar to central tar distilleries for the more elaborate treatment, and probably for blending with other vertical retort tars, but, of a very large number of samples of continuous vertical retort tars that has been examined, only a very small fraction have not been amenable to treatment by means which are simple and which will give a first-class road tar. I have come across one or two which are difficult, and I think Mr. Copp's is one of them.

Reference has been made to the specification, and we might remind ourselves of its history. It is a specification which attempts to make certain that the tar produced is a satisfactory road tar. There is no test which is conclusive and final in determining what is a satisfactory road tar. A number of properties are necessary, but the property or combination of properties cannot be determined by a straight test. It has been found by straight distillation that horizontal retort tar does give a very satisfactory road tar—either No. 1 or No. 2. Consequently, in order to ensure that other tars are right, the test for specific gravity has been kept high. But there is a very big gallonage of tar being used to-day, which is giving at least as much satisfaction as the very best horizontal tar, but which has a specific gravity below that set by the Road Board's specification. Consequently, if in a particular district, isolated from a distillery, the gas engineer desires to get rid of his tar for road purposes and produces a tar which, in my view, would be entirely satisfactory, but with this lower specific gravity, semi-trained surveyors will not accept it. I think the position is a little different now, because the County Councils are dealing with tar more than the Urban District Councils are; but in the past the smaller surveyors, in order to protect themselves, have stuck rigidly to the specification—and rightly so. I believe we are responsible for the specification, and if we have a specification which does not fill the bill it is not the fault of the surveyor. In the case of vertical retort tars which do not comply with the specific gravity test, however, it is possible, by a suitable simple distillation and blending—blending with its own constituents—to produce a road tar which does comply with the specific gravity test. That is so in nearly all cases, but not quite all. Where there is difficulty, bitumen might assist, and where bitumen will assist, bitural should assist. That is where bitural should be of some help. I think there is a need for a great deal more independent research work—independent of the vested interests of the tar distillers. It would be a very good thing, therefore, if the Institution could see to it that experimental and research work was carried out on the problem of converting an amount, which is, after all, about 5 per cent. of the 75 per cent. of vertical retort tar into first-class road tar. That is the problem, but it can be solved.

ROAD TAR FROM COKE OVENS.

Mr. L. H. SENSICLE (London): A few years ago I had some experience in preparing road tar from coke oven tars. In those days it was considered necessary to add a certain amount of bitumen to the coke oven tar, even in order to make it comply with certain proprietary specifications. It may be that those specifications were unnecessarily drastic; but at the same time I suggest it might be contended that there is something in what Mr. Broadhead has stated about the effect of unsaturated hydrocarbons in road tar, in forming brittle compounds on exposure in the road. I do not quite know what is the weathering test that he is referring to, but I believe there is a test in which the material is exposed to ultra-violet light, and an accelerated weathering results. It is understandable that these unsaturated compounds would polymerize under the action of ultra-violet light.

Mr. Broadhead's process is very interesting technically, but it certainly seems very doubtful commercially. Incidentally, one wonders whether it might not have some application to low-temperature tar, which is notoriously abundant in unsaturated compounds. Of course, in continuous vertical retort tar there is a slight tendency towards the characteristics of low-temperature tar. That may be the reason why Mr. Broadhead considers that some treatment of this kind is necessary. In all probability the Australian coals have a greater tendency to produce unsaturated compounds in low-temperature tar, although I would suggest that possibly the extended steaming—in other words, the calorific value of the gas made—may have some influence on the character of the tar produced in continuous vertical retorts. The greater the steaming, possibly, the greater

the amount of unsaturated compounds. It will be noted that Mr. Broadhead claims the cost of this treatment to be 2d. per gallon of tar treated, whereas the selling price of road tar in this country averages less than 2d. A further point I noted was that bitumen in the Commonwealth cost, last year, 4·8d. per gallon, but in ascertaining his profits from the bitural process he assumes a price of 6d. per gallon. Again, therefore, the commercial prospects seem doubtful. I notice that he refers to the parallel case of the polymerizing of unsaturateds in coal gas to form gummy deposits. I have had a little experience of this, and, curiously enough, it was not associated with vertical retort gas but with horizontal retort gas; it seems to me that cooled gas in any case can only carry a certain amount of unsaturated hydrocarbons, and that the process by which the gas is made really does not concern the matter. Gummy deposits were formed on governor bells or valves, and in one or two cases on the valves of meters. This did not occur until gas-oil was used for benzole washing and naphthalene extraction. The explanation appeared to be that previously the creosote used had contained phenolic bodies, and these had been present in sufficient quantity to allow the passage of a little phenolic compound into the gas, which compound would act as an inhibitor of polymerization. The gas-oil contained none, and the inhibitor was, therefore, non-existent. It is a very interesting point.

A process with which I have been associated, for making road tar, might be of interest to you. It is a process for producing a tar with a very low tar acid content and a low naphthalene content by extracting the tar from the hot gases. Tar acids and naphthalene pass forward and do not enter the tar to anything like the extent they would do normally—perhaps to less than half the normal extent. The tar is thus suitable for road purposes; its viscosity is nearly right, and it has only to be dehydrated. I should like to know from Mr. Broadhead whether the so-called fixed tar acids are soluble in water and would be likely to pollute streams when the bitural material is used on the roads.

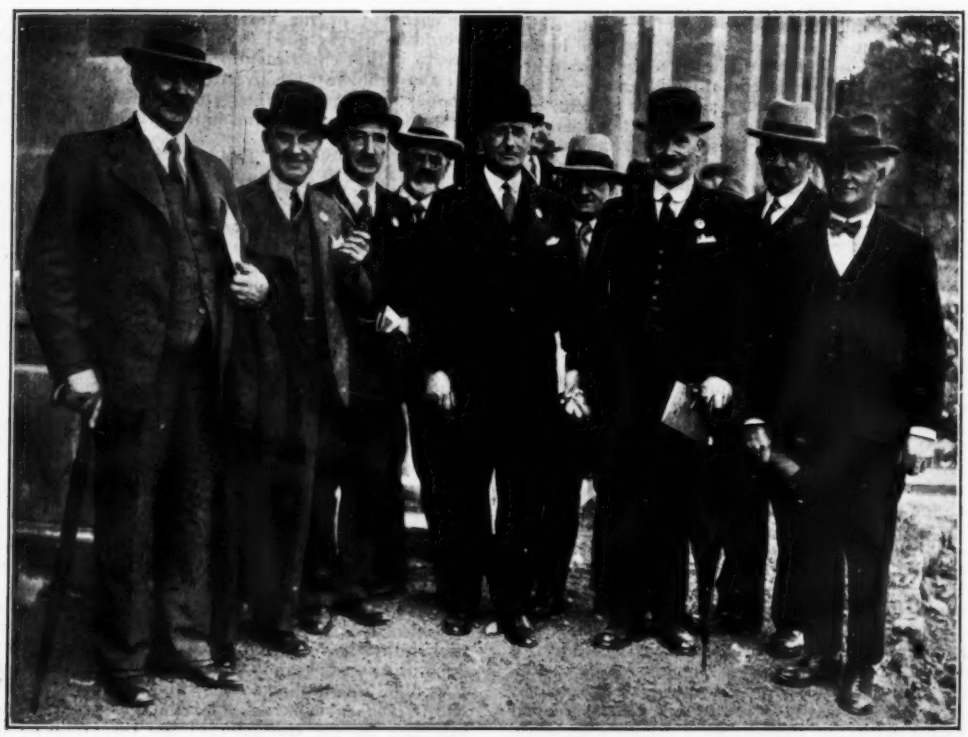
In conclusion, I should like to add that I have found this paper extremely interesting.

Mr. F. FIRTH (Leeds), in a written communication, stated: I must congratulate Mr. Broadhead on his interesting and instructive paper; he has sounded a warning note which I think justifies a careful examination of the tar situation in this country. He connects all his troubles with the introduction of continuous verticals, and also suggests that meter diaphragm troubles have the same origin. Indene and styrene were found to be the bodies responsible for this state of affairs, and steps were taken to deal with the matter. I would like to ask the nature of the damage these bodies have on meter leathers, and the methods adopted to remove them from the gas.

I have heard of troubles being experienced with gummy deposits on meter slide valves where the gas-oil used in the naphthalene washer was held responsible. In another case the seatings in a station governor became covered with a gummy deposit, and this happened on a works which had no verticals or water gas plant, so that it would appear that gumming troubles can occur under any gas-making conditions, and it is generally assumed that the responsible bodies are unsaturateds. Oxidation and polymerization can change unsaturateds in the gaseous state into higher boiling gummy bodies which would cease to be gases and be liberated in the solid state probably as a fine fog, and meter slide valves or seatings of governors are very likely places for the deposition of this fog. My point is that this change of state can occur anywhere in the distribution system, and it is the resultant bodies and not the original unsaturateds which cause troubles, consequently the problem becomes a complicated one to deal with. Some means of retarding polymerization such as the use of inhibitors would be worth investigation where gumming troubles are being experienced.

Mr. Broadhead, when discussing the methods of changing the nature of the hydrocarbons in tar, dismisses cracking as a method which would deteriorate rather than improve the tar; but if horizontal tar is the desired standard, and the original difference between the two is largely the result of the changed cracking conditions in each process, the possibilities of changing the nature of continuous vertical tar by a modification of the original treatment is worth consideration. In both horizontal and continuous vertical practice the nature of the tar is accidental to the process, and it would be a matter for examination whether a change of these conditions could be made a practical proposition.

In the preparation of bitural the tar acids are spoken of as an aid to polymerization of the unsaturateds in tar, and in the process are fixed by formaldehyde. Hoffert in stabilizing benzole uses a tar acid to retard polymerization, and I suggest that the explanation of the apparent paradox may be that Mr. Broadhead in fixing the tar acids by formaldehyde destroys their inhibiting properties and leaves accelerators which are already present a clear field to speed up polymerization. If this theory is correct, the removal of the inhibitors present might be less expensively and more easily done by means other than with formaldehyde. In addition, accelerators are known which speed up polymerization, and no doubt the time taken for the process could be reduced. Finally, the possibilities of stabilizing road tar against further deterioration when in use might profitably be examined.



AT THE FOUNTAIN HEAD.

Heat Transmission

with particular reference to Modern Methods of expressing Convection Data.

By MARGARET FISHENDEN, D.Sc., F.Inst.P.,

Fuel Research Division of the Department of Scientific and Industrial Research.

During the past two or three years, in connection with the work of the Fuel Research Division of the Department of Scientific and Industrial Research, many data on heat transfer have been collected and correlated, and, since it is believed that these would probably be of more general interest, they are shortly to be published in book form.* The aim of the book is to give as complete an account as possible of the present state of knowledge in regard to heat transfer by radiation, conduction, and convection, and of the material available for making numerical calculations. The Director of Fuel Research has given permission for a brief account of some of the ground covered to be presented on this occasion. It would obviously be impossible to deal comprehensively here with all of the numerous branches of the broad subject of heat transfer; for instance, no attempt has been made to discuss the interesting problem of gas radiation, nor have methods of calculating heat flow in the unsteady state been considered. The object of this paper is simply to indicate certain modern methods of correlating and applying available data, particularly in regard to convection.

The gas engineer in many sections of his work is faced by problems of heat transfer. Carbonization processes themselves depend for their success upon the rapid and uniform transmission of heat to the charges of coal in the retorts, while the effective utilization of the resulting gas and coke rests essentially upon a knowledge of the laws of heat transfer. Unfortunately these laws are so complicated as to preclude the possibility of formulating simple generalized rules, but when individual cases are dealt with valuable assistance can often be obtained with comparatively little labour. Since the available literature is incomplete and often unreliable, it is perhaps not out of place to deal briefly here with the mechanism of heat transmission, especially as notable advances, particularly in regard to the action of convection, have been made in recent years; examples of the methods by which the available information can be applied to practical problems can then be given.

HEAT LOSS FROM WARMED SURFACES.

From any surface maintained at a temperature higher than that of its surroundings, heat is lost not only by convection to the surrounding air, but also by radiation to relatively cool surrounding surfaces. The rate at which heat is dissipated by convection varies with the temperature and velocity of the neighbouring air; the colder the air and the more rapid its movement the quicker is heat abstracted. The loss of heat by radiation, on the other hand, depends not upon the air temperature but upon the temperature and nature of the surrounding surfaces, such, for example, as walls, floor, neighbouring bodies, &c.; the colder these are, the more rapid is the net radiation loss, irrespective of whether the air be warm or cold.

RADIATION.

Opaque materials with non-reflecting surfaces, which in academic language are described as "black," are the best radiators, unit area of a freely exposed and "perfectly black" surface at T° Fahr. (Absolute) losing energy by radiation at the rate of $17 \times 10^{-10} T^4$ B.Th.U. per square foot per hour. In order to obtain the radiation emission from actual surfaces, which never attain perfect blackness although in certain cases they very closely approach it, this expression must be multiplied by a fraction e, known as the emissivity, which depends both upon the nature of the surface and upon its temperature, being always very small for polished metals and approaching unity for dull black surfaces. Now every body, as well as radiating to its surroundings, receives radiation from them. In "perfectly black" surroundings at t° Fahr. (Absolute) a surface of emissivity e_1 receives radiation equivalent to $17 \times 10^{-10} t^4$ B.Th.U. per square foot per hour, of which it absorbs a fraction equal to e_1. Thus its net radiation loss, given by the difference between radiation emitted and radiation absorbed, is $17 \times 10^{-10} e_1 (T^4 - t^4)$ B.Th.U. per square foot per hour, an expression which is often erroneously applied in cases where the emissivities of the surroundings are widely different from that of a "black body."

The net radiation loss from any body at a given temperature (T) completely surrounded by other surfaces at temperature t is a maximum when the surroundings are non-reflecting—*i.e.*, perfect absorbers. If, however, the surroundings are not completely absorbent, the radiation loss depends upon the emissivity, e_2, of the surroundings as well as upon e_1, and is also subject to modifications according to the shape of both body and surroundings and their relative positions. The variations are due to the different proportions of the initial radiation which are reflected (either regularly or diffusely) back to the radiating body by its surroundings. The loss is a minimum when all the radiation reflected from the surroundings returns directly to the body. This happens in the case of two parallel plane surfaces whose linear dimensions are large compared with the distance separating them, (say) for instance, the interior surfaces of a hollow wall. The radiation loss from the hotter body in such a case can be shown to be—

$$17 \times 10^{-10} (T^4 - t^4) \left(\frac{e_1 e_2}{e_1 + e_2 - e_1 e_2} \right) \text{ B.Th.U. per square foot per hour.}$$

It is not desirable here to go into detailed mathematical considerations of the radiation interchanges in other geometrical systems; but it is useful to note that the net radiation from a body of emissivity e_1 and temperature T, in complete surroundings of emissivity e_2 and temperature t, must always lie between—

$$17 \times 10^{-10} e_1 (T^4 - t^4) \text{ and}$$

$$17 \times 10^{-10} \frac{e_1 e_2}{e_1 + e_2 - e_1 e_2} (T^4 - t^4) \text{ B.Th.U. per square foot per hour.*}$$

Thus if e_1 and e_2 are both 75 p.ct. maximum "black body" emissivity, the net radiation must lie between 0·75 and 0·60 times $17 \times 10^{-10} (T^4 - t^4)$; or if e_1 and e_2 are 50 per cent., between 0·50 and 0·33 times $17 \times 10^{-10} (T^4 - t^4)$.

For non-visible radiation of long wave length, e for most surfaces except metallic ones (for instance, for painted surfaces varying from dead black to glossy white, for bare cast iron, plaster, or brickwork) is generally about 0·9. For aluminium or bronze paint it varies from 0·4 to 0·7, while for polished silver or copper it may be less than 0·05. For any ordinary surroundings e_2 would thus usually be about 0·9, and as the two expressions given can then never differ by more than 10 per cent., whatever the value of e_1, the simpler one is usually applicable with sufficient accuracy to industrial heating problems.

Selective Emitters.

The laws of radiation enunciated apply only to black bodies and to bodies whose emissivity, expressed as a proportion of that of a black body, is the same at all temperatures (*i.e.*, grey bodies). In practice many ordinary surfaces may be regarded as approximately grey, but care must be taken in dealing with materials possessing marked "selective" properties—*i.e.*, having widely different emis-

* By the present author in collaboration with Mr. O. A. Saunders, M.A., M.Sc.

* See Proc. Phys. Soc., Aug., 1929, p. 569.

sivities for different temperatures. In such cases it is essential to take into consideration the relation of emissivity to wave length.

Surfaces which behave selectively when exposed to radiation may in certain circumstances even attain higher temperatures than black surfaces, or lower temperatures than polished surfaces. For instance, the radiation received from the stars, at the distance of the earth, is very feeble, and an insulated black surface if exposed outside the earth's atmosphere even to a very hot star would rise in temperature only a small fraction of a degree before a balance was attained between the energy absorbed from the star and the energy radiated back to space. On the other hand, if the black surface were replaced by a surface possessing strong absorption for short ultra-violet waves, such as mainly comprise the star radiation, but with no absorption for longer waves, a very high equilibrium temperature would be attained, although, of course, the rate of absorption of energy would be much lower than for the black surface. This is because the new surface, since it absorbs only in the ultra-violet, can emit also only in the ultra-violet; thus, although the rate of rise of temperature is very small, the surface, since there is no counterbalancing loss of energy, continues to get hotter and hotter until ultra-violet emission begins and becomes sufficiently intense to counterbalance the energy absorbed from the star.

Again, suppose a white-painted surface and a polished metallic surface having approximately the same absorbing power for solar radiation to be both exposed to sunlight. Coblentz* has shown that the selective properties of common white paint are such that, while it is a poor absorber (good reflector) for the wavelengths of solar radiation, it is a good absorber, and emitter, for the wavelengths associated with the relatively low temperatures attained. The painted surface, therefore, gets rid more quickly than the polished surface of the heat absorbed, and, since this is the same in both cases, in consequence attains equilibrium at a lower temperature than the polished surface.

The coolness of white clothing in summer is due to the fact that, like white paint, although it is a poor absorber of sunshine, it is a *good* emitter of long wavelength heat radiation.

NATURAL CONVECTION.

When any object is kept at a temperature above that of the surrounding air, a circulation, known as natural convection, is set up in the air. The layer of air in contact with the warm body receives heat from it by conduction and rises in consequence of its diminished density through the cooler and heavier air around it, which flows in to take its place and in turn follows the same sequence.

The rate at which heat is removed from, or imparted to, unit area of the surface of a body through the natural convection currents which it sets up in a surrounding fluid at a different temperature depends upon its size, shape, and inclination to the vertical, as well as upon the nature of the fluid and the temperature difference. Further, the heat transfer may be modified through the interference of other surfaces with the convection streams.

With so many variable factors affecting the heat flow it is not at all a simple matter to establish formulæ and laws which will enable the heat transfer under any given set of conditions to be calculated. Early experimenters obtained results for the cooling in air of a few bodies of simple shape, in terms of temperature difference and surface area; but they were not in a position to deduce generalizations as to the effects of size, shape, &c., from the limited material at their disposal. Frequently, indeed, only the over-all coefficient of cooling was determined, no attempt being made to separate radiation and convection. Even at the present time the experimental results available do not cover by any means the whole range of conditions, but fortunately, as will be seen later, progress has been made in their correlation.

Attention has been devoted mainly to measurements of the cooling in air of planes and horizontal and vertical cylinders of various sizes; but a few investigators have examined the problem for gases other than air, and for water, oils, &c.

It appears that over a fairly wide range of conditions the rate of heat loss by natural convection per unit area is to a close approximation proportional to the $\frac{5}{4}$th power of the temperature difference (θ) between a surface and the medium enveloping it, and may thus be written $C\theta^{\frac{5}{4}}$ where C is constant for a body of given size and shape; although the exact power of θ applicable depends somewhat upon the absolute size of the exposed surfaces, different observers having obtained values varying from 1·33 for very large bodies down to 1·20 or less for very small bodies, such as fine wires, particularly for small differences of temperature.

In order to make numerical calculations of the rate of heat loss by natural convection in any particular case, it is necessary to know the value of C applicable. Direct experimental determinations of this constant are available under certain limited conditions, but systematic information in regard to the variations effected by shape, size, and position is still lacking. One important result, however, which has been substantiated by the work of a number of experimenters is that for bodies of linear dimensions above about a foot, the rate at which heat is lost by natural convection from unit area of a warm body is nearly independent of absolute size; although for bodies of linear dimensions below a foot it increases more and more rapidly as the size diminishes.

(*a*) *Plane Surfaces.*

For isolated plane vertical surfaces of linear dimensions not less than about a foot, several observers have shown that natural convection is equivalent to between $0{\cdot}29\theta^{\frac{5}{4}}$ and $0{\cdot}31\,\theta^{\frac{5}{4}}$ B.Th.U. per square foot per hour, where θ is the temperature difference between the surface and the surrounding air. For horizontal surfaces less definite information is available; Langmuir,* working with a hot disc, $7\frac{1}{2}$ in. in diameter, found coefficients of 0·32 and 0·14 respectively, according as the convecting surface faces upwards or downwards. Griffiths and Davis,† on the other hand, obtained corresponding values of 0·38 and 0·20 for a rectangular sheet 4 ft. square. Although these results are rather divergent, they may be reconciled in the light of further knowledge, and even as they stand they are sufficient to assist in estimates of heat loss where horizontal surfaces must be taken into account.

It is evident that the process of heat *loss* by natural convection from a hot plane horizontal surface facing upwards is identical with that of the *gain* of heat by a cold horizontal surface facing downwards, the temperature difference between surface and convecting medium being the same in magnitude in each case, although opposite in sign. The coefficient of convection loss for a hot surface facing upwards must, therefore, be used in calculating the heat transfer to a cool surface facing downwards; similarly the coefficient for a hot surface facing downwards is to be applied to a cool surface facing upwards. More generally the heat loss from a surface of any shape is the same as the gain of heat by the same surface turned upside down, the surface being, of course, as much warmer than the medium in the first case as it is cooler than the medium in the second case. It is important to know, however, that the presence of other surfaces which may baffle or divert the convection currents will affect the magnitude of the heat transfer; for instance, in the case of convection heat transfer to a cold floor or from a warm ceiling, owing to the fact that the layer of air cooled by contact with the floor or warmed by contact with the ceiling is in stable equilibrium, is usually considerably less than that for isolated surfaces, to which the above figures refer, although, owing to edge effects and the effects of uneven heating, it is never completely eliminated. For a large panel built in flush with the ceiling, a value of about $0{\cdot}10\theta^{\frac{5}{4}}$ was recently obtained in the laboratories of the National Radiator Company.

Several investigators have shown that the air streams in the proximity of a warm vertical surface extend only for a short distance and that the introduction of a parallel surface at a distance away of more than about an inch does

* U.S. Bureau of Standards Reprint, No. 196. Technologic Paper No. 254.

* Trans. Amer. Electro. Chem. Soc. 1913, **23**, 299.

† Food Investigation Board Special Report No. 9.

not affect the rate of convection heat transfer, although, if brought nearer than this, it causes a reduction. The effect of baffles is difficult to estimate other than by direct experiment, especially as the mechanism of convection is still very incompletely understood; in most cases baffling decreases convection, but some dispositions may increase it.

(*b*) *Horizontal Cylinders.*

For large horizontal cylinders the natural convection heat loss per unit area is nearly the same as for large vertical planes. In fact, a coefficient of about 0·3 can be applied sufficiently accurately to most large bodies, provided the surface does not possess re-entrant portions which interfere with the free convection currents. For small cylinders the convection transfer per unit area for any given temperature difference increases more and more rapidly as the diameter decreases. Since the radiation per unit area is independent of size, this fact finds a useful application in the measurement of the temperature of air or other gas in close proximity to surfaces at a different temperature. In such cases the readings of an ordinary mercury thermometer may be seriously affected by radiation from or to the neighbouring surfaces, and is well known to be unreliable; but, if thermocouples are used, the finer the wires of which they are composed, the nearer will be their temperature to that of the air. The value for the air temperature may thus be arrived at by extrapolation of the indications of two or three thermocouples of decreasing diameter. Indeed, except in extreme cases, a single thermocouple of reasonably fine wire will indicate a temperature not far from the true one.

FORCED CONVECTION.

When mechanical means are used to force air over a surface at a different temperature, the heat transfer effected is described as forced convection. In common with natural convection, forced convection depends upon the size and shape of a body as well as upon the temperature difference and velocity of the air stream. Both Rayleigh* and Boussinesq† inferred from theoretical considerations that forced convection should be proportional to the first power of the temperature difference between a body and the air currents traversing it, and this has been confirmed experimentally by many observers. The way in which the rate of heat transfer varies with the velocity of the air, however, is closely dependent upon both the shape and the absolute size of the imposed body. Such a result is not unexpected, since the nature of the air streams around bodies of different shape, such (say) as a plane and a cylinder, will be entirely dissimilar.

Boussinesq's theory for a fluid streaming across a cylinder indicated that H is proportional to $\sqrt{V}$, and Russell‡ arrived at a similar result for stream-line motion in a pipe. A number of experimenters, for instance, King§ working with fine wires, Compan‖ using a sphere 2 cms. in diameter, and Langmuir¶ with a 19 cm. metal disc, have also been able to express their results in terms of $\sqrt{V}$. Hughes,** however, who investigated the case of larger cylinders of varying diameter subjected to a cross stream of air, obtained values proportional to $V^{0·55}$ for diameter 0·17 in. to $V^{0·98}$ for diameter 6·2 in.; while Nicholson,†† Reynolds,‡‡ and others have suggested that for bodies of relatively large size the convection heat loss varies as V. The $\sqrt{V}$ law thus seems fairly well established for small bodies, but for larger bodies the power of V applicable is less certain. Most of the experimental investigations for liquids or gases flowing through tubes have been expressed in terms of powers of V between 0·7 and 0·8. The rate of heat transfer by forced convection can thus be written $B\theta V^n$ B.Th.U. per square foot per hour, but before numerical calculations can be made for any given case it is necessary to know the value of B as well as the power of V applicable.

(*a*) *Heat Transfer between a Tube and a Fluid Flowing Through It.*

The heat transfer per unit time, per unit area of the inside tube surface, per degree difference in temperature between the fluid and the tube walls is usually termed the "Heat Transfer Coefficient," and will be denoted by "a." The most important variables which govern the value of this coefficient are the diameter of the tube and the velocity and nature of the fluid flowing through it.

For velocities exceeding the critical velocity, or, in other words, for fluids in turbulent motion, the additive evidence supports a law of increase of a with increasing velocity according to a power of V between 0·75 and 0·83; and a law of decrease of a with increasing tube diameter according to a power of d between 0·25 and 0·13. Expressed symbolically, a is proportional to $\frac{V^n}{d^m}$ where n lies between 0·75 and 0·83, and m between 0·25 and 0·13. For example, taking as approximate values $n = 0·8$, $m = 0·2$, the effect of doubling the velocity would be to multiply a by 1·74; while doubling the tube diameter would reduce it 0·87 times.

Fluids of different chemical composition behave very differently as regards convection heat transmission, and it is, unfortunately, not possible to deduce the results for one fluid by applying a constant factor to the corresponding results for some other fluid. The factor applicable depends upon the particular circumstances, such as velocity, temperature, tube size, &c., but rough comparisons may be made between different fluids by means of the similarity curves from which the coefficients of heat transfer are calculated.

The heat transfer in a bent tube is greater than that for a similar straight tube. Jeschke,* for instance, found experimentally that air flowing through a tube of diameter d, bent into a circle of diameter D, lost heat 1·2 and 1·6 times more quickly than a similar straight tube for values of $\frac{D}{d} = 18$ and 6 respectively. For tubes of non-circular cross-section the diameter should be taken as twice the hydraulic mean radius—*i.e.*, as $4 \times \frac{\text{cross-sectional area.}}{\text{perimeter}}$.

(*b*) *Heat Transfer between a Plane Surface and a Fluid Flowing Across It.*

Very few systematic investigations of the heat transfer from or to a plane surface in a current of air have been made. Nusselt and Jurges† found that the convection heat loss from a copper plate in alignment with one of the vertical walls of a wind tunnel, and maintained at 122° Fahr. by electrical means, was given by the expression $(1·02 + 0·0035V)\theta$ B.Th.U. per square foot per hour for velocities up to 1000 ft. a minute, and by $0·020V^{0·78}\theta$ for velocities above 1000 ft. a minute, the temperature of the air current being 68° Fahr. Results obtained by Doherty and Carter‡ suggest that the heat transfer is considerably greater when the air blast is directed at 45° to a plate than when it is directed along it.

Heat Transfer Through a Wall or Partition.

The heat transferred through a wall must first be communicated to the inner wall surface; then after passing by conduction through the mass of the wall it is dissipated from the outer wall surface to the outside surroundings. It is customary to make use of surface coefficients of heat transfer such that the heat transmitted from a surface at temperature T° to air at temperature t° may be written K (T − t) where K takes account of both radiation and convection. This practice is defensible only so long as the temperature of surfaces in the neighbourhood are substantially the same as that of the air, and even when this condition is fulfilled it is apparent that K must vary with the absolute temperature, since neither

* Nature 1915, **95** (2368), 66.
† Comptes Rendus 1901, **133**, 257.
‡ Phil. Mag. 1910, **20**, 591.
§ Phil. Trans. R.S. 1914, **214**, 373.
‖ Ann. de Chimie Phys. 1902, **26**, 482.
¶ Trans. Amer. Electro. Chem. Soc. 1913, **23**, 299.
** Phil. Mag., May, 1916.
†† "Engineering," Feb., 1909.
‡‡ Trans. Manchester Lit. and Phil. Soc. 1874–5.

* Sonderheft der L.V.d.I. 1925.
† Gesundheits-Ingenieur, Dec., 1922.
‡ Trans. Amer. Inst. Elec. Eng. **43**, 1924.

radiation nor convection is proportional to the first power of the temperature difference. The expression for surface heat transfer is more correctly written :

$$C (T - t)^{\frac{5}{4}} + 17e_1 \times 10^{-10} (T^4 - t_s^4)$$

where t_s is the effective temperature of the surroundings and is not necessarily equal to the air temperature t; this expression, as already stated, requires further modification if the surroundings are not approximately black, but, fortunately, is applicable with sufficient accuracy to most ordinary cases.

When a steady state has been attained it is obvious that the rates of heat transfer to the inner wall surface, through the wall, and from the outer wall surface, must all be equal. Making use of the simplified expression, we may thus write :

$$H = a_i (t_i - T_i) = \frac{k}{d} (T_i - T_o) = a_o (T_o - t_o)$$

where H is the rate of heat transfer per unit area, k the absolute conductivity of the material of the wall, a_i and a the inside and outside surface coefficients respectively.

It follows that—

$$H = \frac{t_i - t_o}{\frac{1}{a_i} + \frac{1}{a_o} + \frac{d}{k}}$$

For thick walls built of insulating material, d/k is large compared with $\left(\frac{1}{a_i} + \frac{1}{a_o}\right)$, and the rate of heat transmission will be governed mainly by the absolute conductivity of the wall material itself, the surface finish being of relatively little importance; but, for thin walls built of conducting material, d/k is small compared with $\left(\frac{1}{a_i} + \frac{1}{a_o}\right)$, and the rate of heat transmission will be governed mainly by the surface transfer. For this reason, a sheet of black paper, although its absolute conductivity is very low, transmits more heat for a given air-to-air temperature than a sheet of polished metal of the same thickness. Any alteration in the surface heat transmission tends to bring about such a readjustment of surface temperatures as will re-establish equilibrium between the rates of heat transfer to the inner surface of a wall, through its thickness and from its outer surface.

MODERN METHODS OF CORRELATING CONVECTION DATA.

It has already been pointed out that the rate at which heat is transferred by convection depends upon a number of factors, some of which, such as shape, size, and position, are capable of almost unlimited variation. Experimental determinations are available for only a very limited range of conditions, and without some sort of correlation of the individual results the calculation of the heat transfer under any required conditions may present difficulty if experimental determinations have not been made under similar conditions.

Fortunately there is a method of correlation, based upon the so-called principle of similarity, which enables scattered results obtained under different conditions to be incorporated in a few curves of relatively wide application. For instance, by making use of this principle, it can be deduced that for natural convection in a gaseous medium if—

- H = heat loss per unit area per unit time.
- l = linear size of body.
- θ = temperature difference between body and convecting medium.
- k = thermal conductivity of convecting medium.
- a = coefficient of expansion of convecting medium.
- c = specific heat per unit volume (at constant pressure).
- g = acceleration due to gravity,

then, for any given value of $\frac{ag\theta l^3c^2}{k^2}$, the corresponding value of $\frac{Hl}{k\theta}$ is constant for bodies of similar shape, similarly disposed in regard to their surroundings. Thus by plotting values of $\frac{Hl}{k\theta}$ as ordinates, and of $\frac{ag\theta l^3c^2}{k^2}$ as abscissæ, all the available experimental data for any particular form, (say) for freely exposed horizontal cylinders, can be embodied in a single curve (see Fig. 1), although different experimenters may have worked at different temperatures, or with cylinders of different diameters, or gases of different composition.

Conversely the natural convection loss (H) for a horizontal cylinder of any diameter (l) at any temperature excess (θ), and in any gaseous medium of known conductivity (k), specific heat (c), and coefficient of expansion (a), can be found by calculating the appropriate value of $\frac{ag\theta l^3c^2}{k^2}$, reading off the corresponding value of $\frac{Hl}{k\theta}$, and thus deducing H.

At first sight this might appear to be an unnecessarily complicated procedure, but actually a great simplification has been effected; for, in order to supply all the information given in Fig. 1, six curves showing the dependence of H upon l, θ, k, a, c, and g separately would be required. The existing experimental material is, as a matter of fact, insufficient for the direct construction of these, although by making use of the similarity curve the effects of variations in any of them can be determined.

In Fig. 1 all available data for horizontal cylinders varying from fine wires to 10-in. pipes, and for temperature differences up to over 1500° Fahr., have been included, the values of the constants c (specific heat) and k (conductivity) being taken at the mean temperature of surface and surrounding medium, the value of the coefficient of expansion

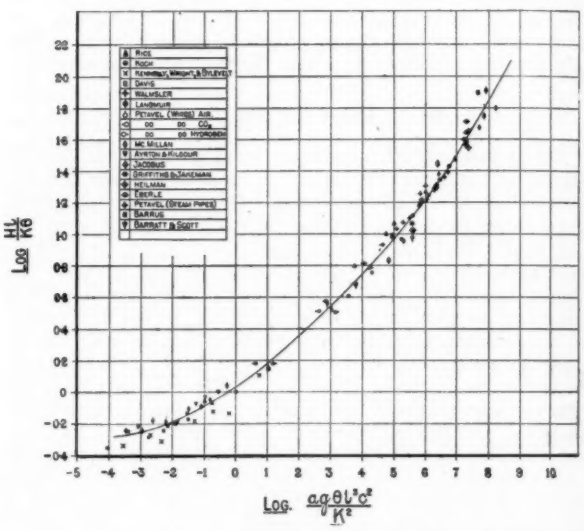


Fig. 1.—Natural Convection from Horizontal Cylinders in Gases (Correlated Data).

(a) at the temperature of the medium. Owing to the extremely wide range of values included it has been necessary to plot logarithms. The majority of the investigations were carried out in air, but results obtained by Petavel* in carbon dioxide and hydrogen are also included. The agreement of $\frac{H}{k\theta}$, for similar values of $\frac{ag\theta l^3c^2}{k^2}$, referring, on the one hand, to a wire in hydrogen at high pressure and, on the other, to relatively large cylinders at atmospheric pressure, is a remarkable confirmation of the possibilities of this method of correlation. Generally speaking, the departure of individual points from the mean curve is remarkably small considering the diversity of their sources.

Most of the points towards the smaller co-ordinates are from results of experiments on wires, while the bigger values come from larger cylinders such as steam pipes. This is because the investigations cover a very wide range of size, and hence, especially since l occurs cubed, its influence is predominant in the expression $\frac{ag\theta l^3c^2}{k^2}$.

For the same temperatures of the surface and medium, and therefore for a fixed value of $\frac{ag\theta c^2}{k^2}$, the heat transfer per unit area, H, depends upon the diameter, l, of the

* Phil. Trans. Roy. Soc. (A.), 1898, **191**, 501.

cylinder according to a law determined by the slope of the curve in Fig. 1. For values of $\frac{ag\theta l^3c^2}{k^2}$ above about 10⁶ (*i.e.*, $\log_{10}\frac{ag\theta l^3c^2}{k^2}$ above 6) the slope is very nearly constant, and appears to tend towards the value $\frac{1}{3}$ as $\frac{ag\theta l^3c^2}{k^2}$ increases. Hence, beyond this point, since logarithmic scales have been employed, $\frac{Hl}{k\theta}$ is proportional to $(\theta l^3)^{\frac{1}{3}}$ or to $\theta^{\frac{1}{3}}l$; and $\frac{H}{k\theta}$, therefore, becomes independent of l. At ordinary temperatures this independence of size is reached at a diameter of about 6 in. The actual value of the limiting diameter is not critical, and is not accurately known. Fig. 1 indicates that it probably becomes rather less than 6 in. for higher temperatures; and this might be expected from a theoretical point of view, since turbulent conditions are reached at a lower level in a rising stream of air at high temperatures than at low temperatures.

For values of $\frac{ag\theta l^3c^2}{k^2}$ below 10⁶ (*i.e.*, $\log_{10}\frac{ag\theta l^3c^2}{k^2}$ below 6), the curve departs from a straight line, and from the changing slope it can be deduced that H increases more and more rapidly as the diameter l diminishes. Thus for very fine wires the heat loss per unit area may reach fifty or more times that from a large cylinder at the same temperature.

Owing to the variation of the value of $\frac{agc^2}{k^2}$ with temperature, the law of variation of convection with temperature difference cannot be obtained directly from the slope of the curve in Fig. 1, except on the assumption that the mean temperature of surface and medium is constant; in these circumstances, to which practical problems do not usually conform, a power of θ gradually decreasing from 1·33 for the large diameters to little more than 1·0 for fine wires is indicated. The modification effected by temperature variations in a, c, and k depends upon whether the varying temperature is that of the surface, the air, or both. For the case of an increasing surface temperature in air at constant temperature it can be deduced from the curve that approximate proportionality to $\theta^{\frac{5}{4}}$ is followed over a wide range of size—(say) from 1 in. upwards—and this conclusion is in agreement with systematic experiments carried out by Griffiths and Davis and others under these conditions.

A simple curve derived from Fig. 1, and illustrating the dependence of the heat loss per unit area for horizontal

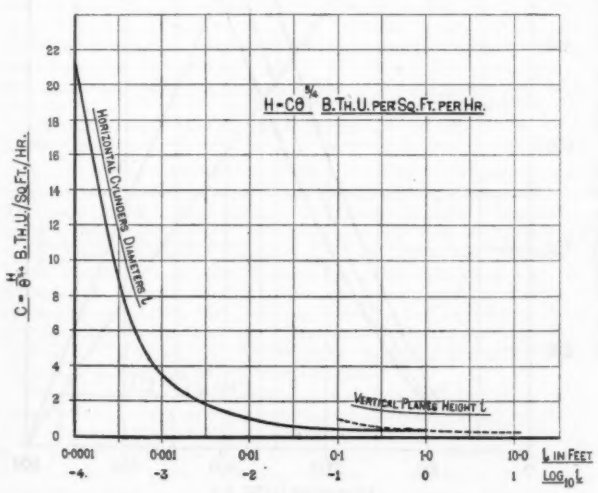


Fig. 2.—Natural Convection: Dependence of Coefficient C upon Size.

cylinders upon their diameter, is given in Fig. 2 for an air temperature at 65° Fahr. The ordinates show $\frac{H}{\theta^{\frac{5}{4}}}$ the abscissæ show the linear dimensions (*i.e.*, diameter in the case of cylinders, height in the case of vertical planes), a logarithmic scale being plotted in this case on account of the wide range covered. For comparison the information available for vertical planes has been included on the same curve. It will be seen that for high vertical planes the coefficient of $\theta^{\frac{5}{4}}$ tends to nearly the same value as for horizontal cylinders of large diameter, but that the increase of the coefficient with diminishing size begins somewhat earlier in the case of the vertical planes.

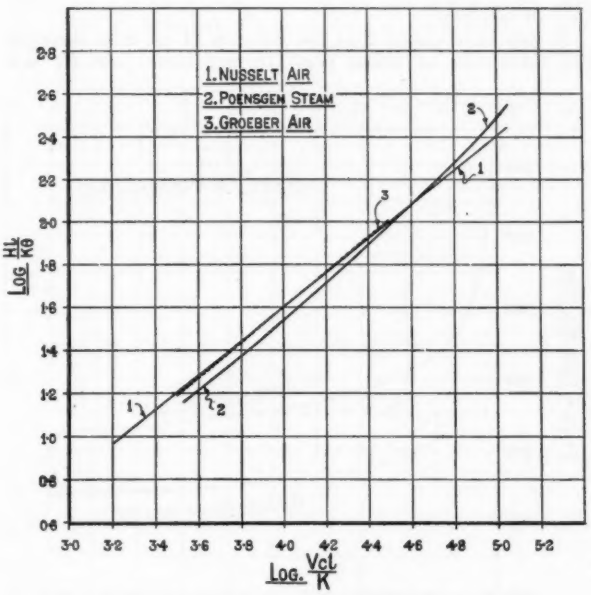


Fig. 3.—Forced Convection (Correlated Data for Flow of Air through Tubes).

The principle of similarity can be employed to bring together in a single curve all the available experimental results for forced convection under any particular geometrical conditions; as an instance the case of a gas flowing through a tube has been dealt with in Fig. 3. It is necessary for this purpose in forced convection to plot $\frac{Hl}{k\theta}$ against $\frac{vcl}{k}$, where H is the heat transfer by forced convection per unit area of the tube surface, l the tube diameter, k the thermal conductivity, v the velocity of the gas traversing the tube, and c the specific heat of the gas per unit volume at the pressure of the experiment. Such a curve contains all the information necessary for the calculation of the heat transfer between a tube of any given diameter traversed at a known velocity by any gas of which the physical constants involved are known. Similar methods can be applied to liquids, but in this case the correlation is less simple. The curve in Fig. 3 includes the results of systematic investigations by three different experimenters, the first working with air at atmospheric pressure, the second with superheated steam at pressures up to 9 atmospheres, and the third with air and carbon dioxide and illuminating gas at pressures up to 16 atmospheres. The velocities investigated extended up to about 100 ft. per second, the temperature differences up to 200° or 300° Fahr. The heat transfer between the gas and the tube is to some extent dependent upon the length of the tube as well as upon its diameter, since the ultimate turbulent conditions are not established immediately the air enters the tube. The results included in Fig. 3, however, are all for horizontal tubes in which the ratio of length to diameter was over 30, and it will be seen that they agree very closely.

From the fact that the experimental curves shown are straight lines with a mean slant of 0·79, it follows that the heat transfer per unit area H is proportional to $v^{0\cdot79}$, and may, therefore, be written $B\theta v^{0\cdot79}$, where B is a coefficient which depends upon the shape and size of the tube and the nature of the gas flowing through it, and can be obtained from the equation to the mean experimental curve $B = 0\cdot0275\left(\frac{c}{k}\right)^{0\cdot79}\frac{k}{l^{0\cdot21}}$. Fig. 4 shows the variation of B for air in circular tubes of varying diameter.

APPLICATION OF SIMILARITY CURVES.

As an example of the use in practical calculations of the data given above, consider the case of a horizontal metal

tube through which hot air is flowing, the external surface of the tube being exposed to air and surroundings at 60° Fahr. The hot air imparts heat to the inner surface of the tube, thereby becoming cooled to a degree depending upon the circumstances. Heat is thus imparted to the internal surface, conducted through the tube wall, and lost by radiation and convection from the external surface of the tube.

It will be assumed that the velocity of air flow through the tube exceeds about 6000 ft. per hour [100 ft. per

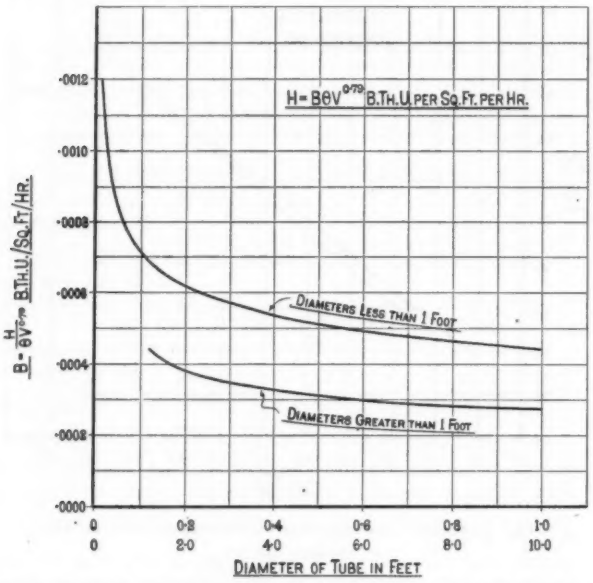


Fig. 4.—Forced Convection: Dependence of Coefficient B upon Diameter.

minute], the laws of forced convection being in consequence applicable to the heat transfer from the hot air to the internal tube surface. In the example a velocity of 100,000 ft. per hour [at atmospheric pressure and 500° Fahr.] has been assumed, and the calculations have been made for two internal tube diameters—namely, 1 ft. and 1 in., the corresponding thicknesses of the tube wall being taken as 1 in. and $\frac{1}{4}$ in. respectively.

Under these conditions preliminary calculations show that (1) the drop of temperature through the metallic tube wall may be disregarded, the internal and external tube surface temperatures being, therefore, taken as equal; and (2) that the drop of temperature of the air along a length of tube equal to several diameters is only a few degrees, with the consequence that over a few feet of tube length the air temperature may be regarded as approximately uniform. In the examples a mean value of 500° Fahr. has been taken.

The heat transfer by forced convection from the hot air to the tube is given by $B\theta V^{0\cdot79}$ B.Th.U. per sq. ft. per hour where

$$B = 0\cdot0275 \left(\frac{c}{k}\right)^{0\cdot79} \frac{k}{D^{0\cdot21}}.$$

For air at a mean temperature 500° Fahr., $\frac{c}{k} = 0\cdot49$ hr./ft.^{2}, $k = 0\cdot021$ B.Th.U./ft.hr. °Fahr., and putting V = 100,000 ft./hr., it is found that :

H = $2\cdot9\,\theta$ B.Th.U. per sq.ft. per hour for the 1 ft. tube.
= $4\cdot8\,\theta$,, ,, ,, ,, ,, 1 in. ,,

These results are represented in Fig. 5, in which the lines B_1 and B_2 show the heat transfer H for any temperature of the internal tube surface, the temperature of the hot air being 500° Fahr.

The loss of heat from the external surfaces takes place by both radiation and natural convection. The radiation loss is given by :

$$0\cdot9 \times 17 \times 10^{-10} [T^4 - 520^4] \text{ B.ThU. per sq.ft. per hour.}$$

where T is the absolute surface temperature, and the surface emissivity is taken as 90 per cent. of black body emissivity.

The natural convection loss is given by :

$$C\theta^{\frac{4}{3}} \text{ B.Th.U. per sq.ft. per hour.}$$

where θ is the temperature excess of the surface above 60° Fahr., and C is the natural convection coefficient for a horizontal cylinder. From the curve in Fig. 1 the value of C is found to be 0·35 for an external diameter 1 ft. 2 in., 0·45 for an external diameter $1\frac{1}{2}$ in.

The total heat loss due to radiation and natural convection together is represented in Fig. 5 by the curves C_1 and C_2 for the 1 ft. and 1 in. internal diameter tubes respectively; in these curves the heat loss is plotted against the external surface temperature, the surroundings being taken at 60° Fahr. The heat loss is expressed per sq. ft. of *internal* tube surface—*i.e.*, the values per sq. ft. external surface have been multiplied by $\frac{1}{10}$ and $\frac{3}{8}$ for the 1 ft. and 1 in. tubes respectively. This is done with a view to equating the values to the internal surface transfer, as in the next paragraph.

Since the temperatures of the internal and external surfaces of the tube are practically equal, their value is given by the abscissa of the point of intersection of the lines B_1 and C_1 for the 1 ft. tube, B_2 and C_2 for the 1 in. tube. The heat transfer in either case is, of course, given by the ordinate of the corresponding point. Reading from the graph, the following results are obtained :

—	Internal Air Temp. ° Fahr.	External Surroundings Temp. ° Fahr.	Internal Tube Surface Temp. ° Fahr.	External Exposed Surface Temp. ° Fahr.	Heat Transfer, B.Th.U. per Sq. Ft. per Hour.
1 ft. tube bare . .	500	60	266	266	685
1 in. ,, ,, . .	,,	,,	278	278	1050
1 ft. tube with slag wool covering 1 in. thick . .	,,	,,	465	102	105

It will be noted that the heat transfer per unit area is

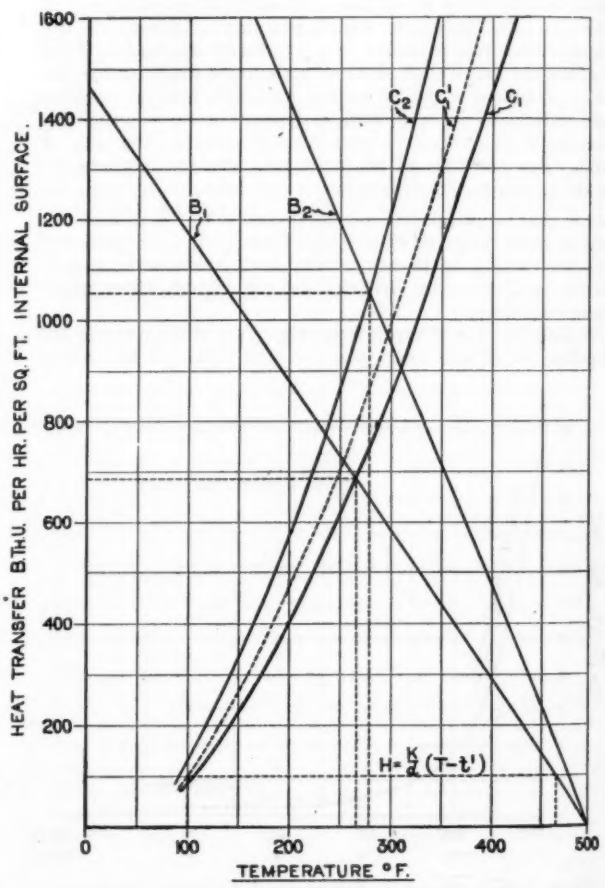


Fig. 5.—Heat Transfer in a Tube through which a Hot Gas is Flowing.

greater with the smaller tube, and also that the smaller tube becomes slightly hotter than the larger one under the same conditions.

If the outside surface of the larger tube is covered with 1 in. of slag wool insulation (conductivity 0·025 B.Th.U. per sq. ft. per hour and ft. thickness), the heat loss is greatly reduced, the internal tube surface temperature

being increased while the external exposed surface temperature is decreased. In order to calculate the heat loss and the various temperatures under the new conditions, Fig. 5 may conveniently be employed. Since the external diameter is increased somewhat by the addition of the lagging, the curve C_1 must be replaced by C_1^1, which represents the corresponding results for an external diameter 16 in. The increase in diameter does not appreciably affect the radiation and convection coefficients, but, when expressed in B.Th.U. per sq. ft. of internal tube surface, the external heat loss is greater for the 16 in. diameter than for the 14 in. diameter in the ratio 16 : 14.

The problem is solved by finding a value of the ordinate H (heat transfer) such that the difference between the corresponding abscissæ of the curves B_1 and C_1^1 (internal and external lagging, surface temperatures T and T^1) is equal to $\frac{Hd}{k}$, where d is the thickness of the lagging and k its conductivity. This can be done quite simply by trial and error. The results are shown in the table above. Reference to Fig. 5 shows that, for an internal tube temperature of 465° Fahr., the forced convection heat transfer (curve B_1) is equal to 105; for an external lagging temperature 102° Fahr. the heat loss (curve C_1^1) is also 105; while the conduction heat transfer through 1 in. of lagging, the surfaces of which are at 465° Fahr. and 102° Fahr. respectively, is again 105.

Sufficient fundamental information is available for obtaining numerical estimates of heat transfer in many other types of problem. Numerous gaps are admittedly still to be found in our knowledge of the laws and coefficients applicable in different cases, but full advantage is often not taken even of easily accessible and easily applied results. It is hoped that this little paper may arouse the interest of those concerned with processes involving heat transfer in the possibilities presented.

DISCUSSION.

The PRESIDENT: This annual conference is devoting most of its time to discussions on industrial problems and we have organized an autumn meeting to hear and discuss the reports of our research committee. By so doing we have not attempted to make a dividing line between the practical and academic (works practice and theory), but rather to give the research reports the full consideration they deserve. Research gives us fundamental knowledge which provides the foundations of progress, but like the foundations of a building they are sometimes overlooked in the admiration of the structure.

Am I not correct in saying that the bulk of the operations in the manufacture and utilization of gas is intimately connected with this very complex subject? Typical examples are the transfer of heat to the coal charge through the retort, the insulation of retort settings, design of cooling plant, &c., and on the utilization side the innumerable problems connected with heating in all forms, cooking operations and so on. All of which indicate the wide application of the principles discussed in the paper.

Mr. C. A. MASTERMAN (Gas Light and Coke Company) said: My chief comment on Dr. Fishenden's paper is to ask for more. The need for a co-ordination of knowledge and information on this important subject is acute, and we may look forward to her forthcoming book in collaboration with Mr. Saunders. I am surprised that Dr. Fishenden, when pointing out the importance of surface finish in connection with heat transmission through thin films, did not mention the use of crumpled metallic foil as a lagging. The material shows very low thermal conductivity and low thermal capacity combined with resistance to relatively high temperatures.

The application of similarity curves developed in the present paper is interesting, and the correlation of results from so many sources with so close an approximation to the curve form is a little astonishing. I shall be interested to know how much of the apparent agreement may be due to the logarithmic expression of the result. It does sometimes happen that a misleading appearance of agreement may be obtained by this method.

Dr. Fishenden in this paper omits any detailed discussion of the mechanism of convection, although I feel sure she has much information which she has not here put forward. In this connection the photographs of Prof. Kirpitcheff produced at the Fuel Conference in 1928 are interesting as giving a clear visual indication of air flow round various heated surfaces under natural convection conditions. On vertical surfaces the three successive states of lamina, curl, and turbulent flow are clearly shown.

The mechanism of convection is, under practical conditions, of great importance, and I would draw attention to an apparent paradox in connection with flue pipes where, by increasing the heat loss, it has been possible to maintain a higher temperature. The troubles connected with condensation in flue pipes are familiar, and condensation must occur if the temperature falls below a certain figure dependent upon the dilution of the products. The important thing is to prevent the development of even local cool areas, since condensation may here occur, even though the mean flue gas temperature is well above the critical limit. Even under turbulent conditions of flow I have found evidence of stratification in the flue leading to a temperature gradient from centre to edge of over 100° Fahr. This may soon lead to condensation in the cool zone near the wall, and the danger has been avoided by the introduction of an elbow or elbows which disturb the cool shell and so prevent any local cool spots—even though the total heat loss is thereby increased. I notice Dr. Fishenden has referred to some results of Jeschke on the same lines, and which may surely be explained in the same way as due to increased turbulence.

PRINCIPLES TOO RARELY APPRECIATED.

Judging by results of the examination of a number of gas-heated appliances, it is clear that the principles of efficient heat transmission are all too rarely appreciated and applied. One feature of gas as a fuel is the complete control which can be exercised so that the heated surfaces may be precisely balanced against the performance required.

In general it is desired to obtain a predetermined heat input with a minimum of area. Several entirely different methods of applying heat from burning gas are available and are applied. By flame contact, which is the commonest method of accelerating input, a very high temperature gradient is obtained, together with a high local velocity due to movement of the gas itself.

Where flame contact is undesirable or impracticable, short wave radiation from incandescent refractory material leads to accelerated heat transfer. The application of this in conversion sets for solid fuel boilers is familiar, but I may mention that good results have been obtained on the other extreme of size, on the "Electrolux" refrigerator. In order to overcome other difficulties, an incandescent clay mantle was tried in place of flame contact, and the results obtained were astonishingly good, although, of course, difficulties of maintenance and the like may make the method impracticable for general use.

Long traverse of flue gases will, of course, lead ultimately to a high input, but, as in flue pipes, local condensation may be expected to occur long before a really high efficiency is obtained.

The use of fins for accelerating heat transfer is becoming increasingly popular, following the Continental and American example. In this case local condensation may usually be re-evaporated owing to the high temperatures of the fins themselves. But the use of fins or gills and the use of studs on cast-iron faces are in some ways undesirable, owing to accumulations of deposits.

Assuming that the normal relatively low rate of heat transfer is due to lamina flow, even though conditions are nominally turbulent, the aim on plane heat transfer surfaces should be to plough-off the cooler layers of gases which have given up their heat and replace them with hot gases. Following this principle I have found it possible to increase the efficiency of a simple water heating unit from under 50 to over 70 per cent. without in any way affecting the heat transfer surfaces themselves. The maximum flue gas velocity has been preserved by stepping down the available area to correspond with the contraction in the gas volume as heat is given up. At the same time successive quantities of hot gases are introduced at right-angles to the heat transfer surface, in order to create a maximum local disturbance and so remove the shell of cool gases which otherwise continues to move in contact with the surfaces, and so reduces the heat transfer rate.

I cannot claim any originality in these remarks on the mechanism of heat transfer, although the persistence of temperature gradient in the moving gases even under nominally turbulent conditions does not seem to have been accepted generally. My hope is that the forthcoming book will contain fuller information than is possible in the present paper, and that each and every one of these methods of heat transfer may receive as adequate and able attention as she has given them in the more limited review which alone has been possible to-day.

THE METHOD OF PLOTTING.

Mr. GILBERT B. HOWARTH (Chief Chemist, Newcastle-upon-Tyne and Gateshead Gas Company) said: Special attention may be directed to the method of plotting that has been used. In Fig. 1, for example, the numerous variables have been collected into two groups, which have been plotted against one another. The process of grouping demands a thorough understanding of the theoretical principles involved, and a considerable degree of mathematical facility; but when once this process is complete, the application of the method is little more difficult than reading a point from a simple graph. This treatment is

not new to the Institution, a similar method having been used some years ago in connection with friction in gas pipes.

The value of a fine thermocouple for taking the temperature of a gas where the surroundings are at a different temperature is very well explained. It must be clearly understood that this advantage does *not* extend to a thermocouple made of thick wire or to one enclosed in a thick protecting tube. The Gas Investigation Committee used couples of various thicknesses for determining gas temperatures on a water gas plant, and in every case the finer wires not only responded more rapidly to variations, but recorded a higher temperature owing to reduction of radiation to the walls of the pipe.

The difference in emissivity between aluminium paint and a true metallic surface is doubtless due to the properties of the medium with which the paint is mixed. This medium is transparent to visual rays and so allows the aluminium to be seen, but absorbs heat rays, and, therefore, acts to some extent as a "black body." Has Dr. Fishenden any information concerning surfaces which have been painted with the medium and then dusted with the dry aluminium powder?

A similar effect is found in the case of a mercury thermometer, where the glass bulb, though transparent to light, is a good absorber of heat, and, therefore, acts as a "black body." It frequently happens that a metal radiation screen is highly polished and then coated with a thin film of lacquer or grease to prevent tarnishing. One would expect such a film to interfere considerably with the heat-reflecting powers of the screen; and it would be interesting to know if this effect has been found experimentally.

May I give an example of the practical application of the theoretical principles dealt with in the paper? A certain hotel not far from here was heated by means of hot water radiators. The black appearance of the radiators and pipes conflicted with the scheme of decoration, and they were replaced by highly polished ones. The management was delighted to find a saving in boiler fuel as a result of the change, but the real effect was *not* greater efficiency, but a slightly reduced heat output from the polished surfaces owing to their lower emissivity.

Mr. JAMES W. WOOD said: I should like in the first place to congratulate Dr. Fishenden upon her treatment of a difficult subject, and to express pleasure that a paper of this character should find a place in the transactions of the Institution. The transmission of heat plays an important part at almost every stage of gas manufacture and gas utilization, and it is, therefore, necessary that we should have precise information as to the laws governing such transfers. In the past we have been content with simple empirical rules and tables embodying the results of experience. The available data are often only vaguely defined and the thermal demands so fluctuating that exact calculation would be a waste of time. The use of such rules and tables will, therefore, survive, as they provide a cheap and rapid method of forming an estimate sufficiently accurate for many practical purposes. At the same time there are research problems (and often commercial problems) in heat transmission where conditions can be defined more exactly, and the issues are so important that the time spent in obtaining a more detailed solution along the lines suggested by Dr. Fishenden would be amply repaid. Even here, there is room for the judgment and experience of the "expert" in selecting the "constants" which are to be used.

THE PRINCIPLE OF SIMILARITY.

The most interesting part of the paper is that involving the principle of similarity, and we look forward with some interest to the promised publication by Dr. Fishenden and Mr. Saunders where this subject will presumably be treated more fully. At present there is no indication as to why such quantities as $\frac{Hl}{k\theta}$ and $\frac{a g \theta l^3 \epsilon^2}{k^2}$ should be associated together, nor why $3l^2$ rather than l^2 should be found in an expression which is concerned with surface losses. One would also expect a viscosity term to enter into the expression. If, however, we accept the principles laid down, one cannot do better than follow step by step the example worked out by Dr. Fishenden, for the arguments are lucid and none of the steps difficult to understand.

We should have been pleased if Dr. Fishenden could have added an example, common in chemical engineering practice, involving a counter-current exchange, or one typical of condenser practice, in which the heat to be dissipated for a given temperature-drop is modified to some extent by the latent heat of condensation.

The question of the ceiling panel is of some interest, as not only is the rate of heat-loss lower than for any other disposition of a plane surface, but one naturally wonders how much of the convected heat reaches the working plane in the room. If this escapes directly, and radiation alone is to be depended upon, the over-all efficiency will be low, and a very high price will be paid for the advantage of unobstructed floor space.

Incidentally, the figures given by Dr. Fishenden for radiation suggest that a temperature somewhat below 800° C. should be attainable with a gas fire, and a radiant efficiency between 40 and 50 per cent. on the gross calorific value. The heat returned by surroundings of ordinary character would only be 1 or 1½ per cent. of the heat emitted.

When dealing with heating by radiation and convection it is somewhat surprising that Dr. Fishenden has not pointed out the great difference in the speed at which heat reaches the more remote parts of a room heated mainly by radiation or convection respectively.

Can Dr. Fishenden express any opinion as to the extent to which the conductivity of porous material, such as fireclay or coke, may be influenced at high temperatures by radiation from cell-wall to cell-wall?

It is not uncommon to paint calorimeter jackets when they become badly tarnished, and light-coloured paints are invariably used. The work of the National Physical Laboratory shows that the colour is immaterial. Has Dr. Fishenden similar information for transparent lacquers of different kinds upon polished metallic surfaces?

The loss of heat by convection is plainly influenced by the character of the surface, for on some apparatus I used some years ago I found that, while a single coat of aluminium paint in the usual amyl-acetate-celluloid vehicle greatly reduced the heat losses, a second coat gave a result between that of the bare and the single-coated vessel. The second coat was rather rough.

The statements regarding paints and clothing are not mutually contradictory, but point to the care required in the use of the terms "sunlight," "sunshine," and "solar radiation," for the precise result obtained with selective bodies generally depends very much upon the spectral distribution of energy in the incident radiation. The unsuitability, owing to radiation effects, of the ordinary mercury-in-glass thermometer for taking air or gas temperatures has been known for years. While Forshaw was working out his oven tests he was able to demonstrate an almost negligible difference between the readings of ordinary and black-bulb thermometers inside the oven.

Again, I recently placed an ordinary thermometer in a polished shield 3 ft. in front of the centre of a 14-in. gas fire. The reading was 59° Fahr. On removal of the shield the temperature rose to 69° Fahr.; while coating the bulb with a matt black paint only raised the temperature a further 2½° Fahr. Both the last temperatures were erroneous as indications of air temperature, and owing to its glass envelope the thermometer was much more nearly "black" than "bright" to thermal radiation.

Despite these difficulties I see no reason why the use of mercury-in-glass thermometers should not be continued, for they are convenient and self-contained instruments, and with suitable precautions will enable one to exercise sufficient control over gas-cooling and condensation processes.

Where thermal losses are being measured as in flue gases, exact temperatures are required and radiation errors must be eliminated. I regret that Dr. Fishenden's arguments do not convince me of the suitability of fine thermocouples for this purpose. In exploring the temperature distribution in a flue, for example (as in Masterman's excellent paper on ventilation and flue equipment), I believe that the temperature gradient along the wires of the couple could materially influence the temperature of the junction when measuring a temperature near the flue wall, and would to some extent account for a slightly askew distribution of temperature across the flue. I should like once more to thank Dr. Fishenden for her fascinating contribution to our meeting.

THE LAWS OF CONVECTION.

Mr. H. J. HODSMAN, M.B.E., M.Sc., F.I.C. (Leeds University), said: I wish in the first place to express the opinion that the subject of heat transmission is deserving of a place in the Transactions of the Institution. The economical design of plant for manufacturing or using gas depends on a right understanding of the laws of heat flow. Speaking personally, I welcome the paper because for some years we have recognized at the University that the training of students should not be limited to the properties of fuels and their manufacture, to the science of combustion—the liberation of the heat of fuels—but should logically include the study of the flow of heat in its applications.

Now the laws of radiation and conduction have long been established, and there is no confusion about their expression. The same cannot be said about convection, the laws of which are presented in various ways by different workers. There has been a difficulty in the choice of a method of presentation to students. We have contented ourselves with plotting the rate of heat transfer against velocity of gas, or at any rate against the weight flow of gas. Such a method requires a separate curve for every size of pipe or other condition.

It is a very useful step forward which has been made in recent years to bring these numerous curves, as it were, into one focus, by the application of the principle of similarity. We arrive at a single curve with which a wide range of experimental data can be tested. These dimensional calculations are a sort of mathematical sleight-of-hand for getting round difficulties which cannot be explained by straightforward means.

As with most conjuring tricks, the onlooker is left guessing—*e.g.*, as to why $\frac{Hl}{k\theta}$ should be plotted against $\frac{a\rho\theta l^3 c^2}{k^2}$. The principle of similarity does not tell us why. Nevertheless, it is a valuable result as is clear from inspection of Fig. 1, which shows that a large number of apparently unrelated observations follow the same law.

Fig. 3 for correlating data on forced convection through tubes is the first attempt I have seen. I have attempted to see whether measurements made in our laboratory at the University agree with the curve. I had some difficulty because there is some uncertainty as to units—*e.g.*, velocities sometimes being mentioned in feet per second and feet per hour. I believe, however, that our data harmonize with those quoted, but would suggest that the question of units should be stated more explicitly in the paper.

Again, Dr. Fishenden has apparently succeeded in eliminating viscosity as a factor influencing heat flow. There is evidently an approximation made somewhere; and it would be interesting to know just where and why it is made. I wish to welcome the paper, which will prove of great service to me personally.

Mr. H. HOLLINGS (Gas Light and Coke Company) said: The invitation of the President to contribute to the discussion on this paper is a pleasure in so far as it gives one the opportunity to express congratulations and thanks to Dr. Fishenden for her paper. It will prove to be a useful work of reference for those engaged upon the design of a wide variety of apparatus and plant used in our industry. In other respects, however, the invitation is a source of some embarrassment, because a mathematical statement of fundamental principles such as this does not lend itself readily to general discussion.

APPLICATIONS TO THE RETORT HOUSE.

It would appear that in writing the paper Dr. Fishenden has had in mind more particularly the problems involved in the heating of buildings. Many members of the Institution, however, will be interested in other applications of her work. For example, the section upon radiation may be studied with advantage by all who are concerned with the use of temperature-measuring instruments in retort houses. The section upon natural convection has a very direct bearing upon those heat losses from retort settings which we usually include with radiation losses in an over-all coefficient of cooling. This is a subject to which the Fuel Research Board have given a good deal of attention.

Heat transfer problems of another kind arise on gas-works in connection with gas condensation plant. The principles enunciated by Dr. Fishenden under the heading of "Forced Convection" are directly applicable to the design of water-cooled condensers and also to the design of coolers for ammoniacal liquor or the washing oil used for benzole recovery. These principles form the basis of the more technical investigation of Walker, Lewis, and McAdams, an account of which has now found its way into several text-books and is well known to students of chemical engineering.

The formula developed by Dr. Fishenden shows that the heat transfer varies directly as the velocity of the fluid raised in the power of 0·79. This is in substantial agreement with the experimental work of Cooper reported to the World Power Conference in 1928, and of the Australian Gas Light Company reported in the "GAS JOURNAL" last September (1929, **187**, 626). In the latter case it is shown by application of the dimensional theory that the heat transfer also varies inversely as the diameter of the tube through which the fluid is flowing, raised to the power 0·23 or 0·24. Dr. Fishenden's value is also in agreement with this.

Fortunately the general principles involved are now realized by most of the designers of condensing plant, and steps are taken to maintain high velocities of gas and water. The practical effect of this is illustrated in the tests which I communicated to the Institution last year in the first report of the Ammonia Committee.

I have been interested to speculate whether the data given in Figs. 3 and 4 have any bearing upon the design of atmospheric condensers. Dr. Fishenden applies them to pipes through which hot air is passing, but by suitable adjustment of the constants they may be applied to air-cooled pipes through which hot gas is passing, and then provide a mathematical illustration of the importance of keeping the diameter of such pipes as low as is consistent with the prevention of naphthalene deposits.

It is unfortunate that, because of the presence of impurities such as naphthalene, the behaviour of crude gas on the works does not lend itself to the same precise mathematical treatment as does the behaviour of hot air.

THE AUTHOR'S REPLY.

Dr. MARGARET FISHENDEN, replying to the discussion, said: It is obviously impossible for me to deal with the whole of the discussion in the short time available, but there are one or two very important points with which I should like to deal. At the outset I would say that the half-hour which was allotted to me for the purpose of introducing the paper was rather a limited time in which to deal with the subject of heat transfer; if you had the patience to listen to me all day, and if I were allowed to talk all day, I should love to do so.

The most important point raised was the question as to how one finds these groups, and I am glad that the point has been raised. As several speakers have pointed out, it is an actual fact that the success of the application of the principle of similarity to this or other problems really depends essentially upon the initial selection of the variables upon which you might expect it to depend. The way one gets these groups is not by a long process of trial and error; it is by a knowledge of the subject. You ask yourself what you would expect convection to depend on. You would expect it to depend on a whole range of things—viscosity, temperature, and so on—and what the principle of similarity tells us is that, provided these groups remain unaltered as a whole, however you alter the individual members of them, the distributions of temperature and of velocity in your system remain unaltered. It is perfectly obvious that the distributions of temperature and velocity do not depend on the system of units in which you measure your variables; they have nothing to do with how you measure them, because these groups are dimensionless. But that, of course, is only what you might call a convenient algebraic dodge for finding the groups. The real success of the application of the principle depends on the initial selection of the things you would expect to go into those groups. For instance, if we expressed heat as energy we should get a different group. As a matter of fact, in convection it is not necessary to do that.

Another important point raised, and about which there seems to be a little misunderstanding, is that of having left viscosity out of consideration. Viscosity has not been left out of account; the fact is that if one is dealing only with gases it so happens that there is a relation between the specific heat and the conductivity and the viscosity, which tells us that $\frac{C\mu}{k}$ is constant, and, of course, C and k come into these groups; but viscosity as such does not come in. This method can be applied to convection from liquids as well as from gases; but in the case of liquids $\frac{C\mu}{k}$ is not constant, and therefore we have to draw a separate group for each liquid, or at any rate for each value of $\frac{C\mu}{k}$. So that the reason why viscosity did not appear is that I have only curves for gases, and in that case the relation is maintained.

(Dr. Fishenden intimated that she would reply in writing to the other criticisms made.)

Gas Dehydration.

By Dr. E. W. SMITH, C.B.E., F.I.C., M.Inst.Gas E.

The subject of gas dehydration—perhaps more correctly termed partial dehydration—is rapidly assuming great importance in the gas and coking industries; and when I was invited by the President to prepare this contribution, it was felt that a very useful purpose would be served if a survey were made of the subject, which should include as much information as possible from all works where gas dehydration had been put into operation.

I am of the opinion that gas dehydration is one of the most important advances that has been made on the technical and commercial sides of the industry in recent years, and the fact that between forty and fifty gas undertakings, from the largest to the smallest, have, after a thorough examination of the *pros* and *cons* of the subject, adopted the process would seem to confirm this view.

It is my desire that this paper should take the form of a report of what has been done, rather than a purely technical and theoretical dissertation; and with the wholehearted co-operation of the contractors who have been responsible for the processes that are in operation, and the gas undertakings that have adopted these processes and have replied to a questionnaire which I addressed to them, this has been made possible.

I wish to express my great appreciation of the assistance I have been given by all concerned, and particularly to Mr. H. M. Spiers for the large amount of work he has done in assisting me to prepare the paper in the time available.

Already the industry is indebted to a number of writers for valuable papers on this subject. These are referred to in the bibliography, and I have made extensive use of them; I am afraid that very little new information of a technical nature can be put forward, as most of the technique has already been dealt with in these papers.

Various methods of gas drying have been touched on, but it must not be assumed that these are the only technical methods available. It is interesting to note that one of the bye-products which would in the ordinary way probably be an effluent of one of the liquid purification processes in America is an excellent gas dehydration agent, and is being used for that purpose.

A subject of equal importance with that of dehydration is that of naphthalene extraction, and it is satisfactory to note that in nearly all cases where dehydration plants have been installed naphthalene extraction has been incorporated with them wherever necessary.

At a time when the cost of distribution is such a material proportion of the total cost of gas to the consumer, it will be readily appreciated that anything that will appreciably reduce these distribution costs is worthy of very serious consideration. With the help of more detailed costing systems the study of distribution costs is made much easier, and will repay serious thought.

I believe that a thorough understanding of details, and a little more imagination, can in many cases reduce distribution costs.

DRAWBACKS ATTENDING THE DISTRIBUTION OF SATURATED GAS.

The drawbacks attending the distribution of saturated gas may be summarized as follows :—

1. *Corrosion Troubles.*

By far the most important factor among the causes of corrosion is the presence of liquid water containing gases, solids, or liquids in solution. Water vapour by itself—that is, in absence of the liquid—is not a source of corrosion even though compounds, which in presence of liquid water would promote corrosion, may be present. Whenever the temperature of a moist gas becomes low enough for moisture to be deposited, conditions favourable to corrosion may develop if accessory compounds are present. This is always the case with coal gas, in view of its content of oxygen, carbon dioxide, ammonia, and hydrocyanic acid; hence corrosion proceeds actively in the gasholder, the mains, the service pipes, and the meters. Other harmful compounds present in the water condensate from coal gas are shown in the following table (from the report of the Life of Meters Committee of the Institution of Gas Engineers, 1919) giving the content of dissolved matter of the liquid obtained in one case from compressed gas on cooling.

	Grains per Gallon.
Ammonium thiocyanate	31·0
Ammonium ferrocyanide	15·0
Ammonium sulphate	4·4
Ammonium sulphide	1·6
Ferrous sulphate	1·3
Carbon dioxide	31·5

Corrosion has in the past been countered by the use of cast-iron or wrought-iron mains and wrought-iron service pipes with the consequence that the cost of distribution has been greater than it would be were the use of steel mains possible.

Meters, also, have become rapidly attacked, involving costly repair bills and a further loss due to faulty registration. Corroded meters usually register slow, and are thus a source of loss of revenue until they can be replaced. The loss is therefore a twofold one, touching both the revenue and the distribution side. In holders, also, corrosion of the interior involves frequent repair bills.

Other drawbacks consequent on corrosion are the partial blockage of service pipes due to corrosion deposits and the increased pressure drop due to the increased friction of the rough corroded surfaces.

2. *Water Deposition.*

The deposition of water in mains and services due to the cooling of the saturated gas in its passage to the consumer involves the need for the removal of vast quantities of water by syphon pumping. One million c.ft. of saturated gas at 60° Fahr. deposit 34 gallons of water on being cooled to 46° Fahr., and a still greater quantity if the cooling range is extended beyond these limits. In addition, water-logged services give rise to loss of pressure and pulsations in the supply, and eventually to complete failure of the supply.

A further feature associated with the deposition of water is the freezing of the water in the services in severe weather causing failure of street lamps.

Table 1 and Fig. 1 show the water content of saturated gas at various temperatures.

Deposition of water, therefore, involves the cost of installation and maintenance of syphons, their frequent pumping, the disposal of the water removed, and the maintenance of a staff of fitters engaged in the work of clearing water-logged or frozen services.

3. *Naphthalene Deposit.*

Water deposit has also an adverse effect on the efficiency of naphthalene removal, since the brushes of the naphthalene washer become wet, due to the drop in temperature of the gas passing through the scrubbers, and the brushes are, therefore, unable to pick up their full quota of oil. The naphthalene which escapes extraction may subsequently be deposited in the mains and services, with consequent blockage unless adequate and costly oil spraying is continuously carried out.

4. *High Figures for Unaccounted-For Gas.*

In winter, gas leaving the works suffers a reduction in volume due, first, to a fall in temperature, and, secondly, to deposition of water. One million c.ft. of gas saturated at 60° Fahr. and 30 in. become 966,000 c.ft. of saturated gas at 46° Fahr. a reduction of 3·4 per cent. Of this, the reduction in volume if the cooling were unattended by deposition of water would be only 2·7 per cent., leaving a reduction of 0·7 per cent. due to the condensation of the water.

An additional cause for the high figure for unaccounted-

TABLE I.—*Water Content and Volume of Saturated Gas at 30 in.*

Basis—1 c.ft. of gas at 30 in., 60° Fahr. saturated.

[Based on Callendar's steam tables.]

Temperature, °Fahr. = t.	Gallons of Water per 1,000,000 C.Ft. of Gas Measured at 30 In., 60° Fahr. Saturated.	Volume of Saturated Gas Assumed at t° Fahr. by 1 C.Ft. of Gas Saturated at 30 In. and 60° Fahr.
32	28·7	0·935
34	31·1	0·939
36	33·7	0·943
38	36·5	0·948
40	39·5	0·952
42	42·7	0·957
44	46·2	0·961
46	49·9	0·966
48	53·8	0·970
50	58·0	0·975
52	62·5	0·980
54	67·3	0·985
56	72·5	0·990
58	78·0	0·995
60	83·9	1·000
62	90·2	1·005
64	96·9	1·010
66	104·0	1·015
68	111·5	1·021
70	119·6	1·026
72	128·3	1·032
74	137·5	1·038
76	147·3	1·044

To obtain gallons of water contained in 1 million c.ft. of gas saturated at t° Fahr. and measured at t° Fahr., divide figures in column 2 by figures in column 3.

Example.—1,000,000 c.ft. of gas saturated at 76° Fahr. are cooled to 44° Fahr. To find—

(1) The volume of the saturated gas resulting at 44° Fahr.
(2) The amount of condensate.
(3) The volume of the resulting gas after reheating to 60° Fahr.

The pressure throughout is 30 in. Hg.

(1) 1,000,000 c.ft. of saturated gas at 76° Fahr. become $\frac{961,000}{1{\cdot}044}$ c.ft. = 920,000 c.ft. of saturated gas at 44° Fahr., water being condensed.

(2) The volume of saturated gas at 60° Fahr., corresponding to 1,000,000 c.ft., saturated at 76° Fahr., $= \frac{1,000,000}{1{\cdot}044} = 958,000$ c.ft.

Hence water condensed $= \frac{958,000}{1,000,000}(147{\cdot}3 - 46{\cdot}2) = 96{\cdot}8$ gallons.

(3) The volume after reheating to 60° Fahr. is

$$920,000 \times \frac{460 + 60}{460 + 44} = 949,000 \text{ c.ft.}$$

WATER CONTENT OF SATURATED GAS.

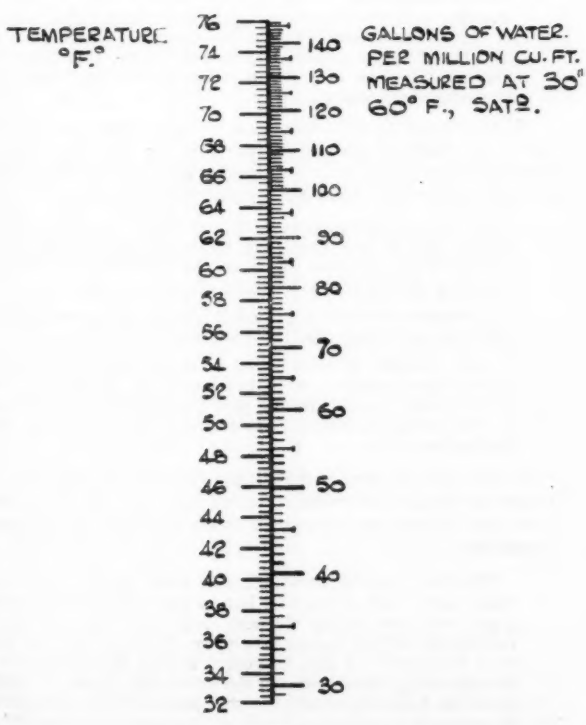


Fig. 1.

for gas is the failure to detect gas leaks in areas in which the mains are in water-logged soil. Due to the recognition that syphon pumping is constantly necessary, inleakage of water due to faulty mains is not noticed, whereas if the mains were normally dry, any water removed at the syphons would be known to be due to faults, and these can be remedied.

ADVANTAGES OF PARTIAL DEHYDRATION OF GAS.

In view of the foregoing drawbacks attending the distribution of saturated gas, the following advantages may be expected to accrue in greater or in less extent from the distribution of partially dehydrated gas.

*(1) Prevention of rust formation in mains and services, and consequent lower maintenance cost.

*(2) Possibility of the use of steel piping for services, leading to lower capital costs and lower maintenance costs.

(3) Elimination of the need for such thorough purification from cyanogen compounds, since in absence of deposited water, cyanogen compounds are far less corrosive, if, indeed, not entirely harmless.

(4) Cost of boosting gas bought in bulk is reduced, since there is less material to compress.

*(5) Cost of syphon pumping is eliminated wholly or very nearly so, and the trouble of disposing of the condensate is obviated.

*(6) Labour costs in attending to stoppages due to water and naphthalene are lessened.

*(7) Services previously water-logged become dried out.

*(8) Freezing of service pipes is eliminated.

*(9) Improved service to consumers.

(10) The oil film becomes more permanent, and hence more effective.

*(11) Steel mains with welded joints can be used instead of wrought iron, and capital and maintenance costs are reduced.

*(12) Leakages are more readily detected and traced.

(13) The quantity of gas sold may be increased, due to the full pressure being always maintained.

(14) The volume of gas in which one therm is contained is lower, and the cost of distribution is lowered due to the presence of smaller amounts of inerts.

(15) Where steaming is carried out, it may be pushed further without loss of the declared calorific value.

*(16) A better knowledge of the unaccounted-for gas is possible, since allowance can be made for the decrease in volume consequent on dehydration by a determination of the dew-point of the gas before and after dehydration.

*(17) Naphthalene removal is more efficient and can be carried out with a smaller volume of wash-oil. The latter point represents a small saving only in pumping costs, since full credit for the reduction in the quantity of gas oil used cannot be taken, as the used oil is subsequently employed for carburetting purposes. On the other hand, in installations having no carburetted water gas plant, and where it is necessary to dispose of the used wash-oil at a loss, the fact that less oil is required as a result of dehydration does represent a financial gain.

*(18) Naphthalene deposits present in the services are gradually absorbed, since the gas after dehydration and efficient stripping is unsaturated as regards naphthalene.

*(19) The interior of the holders is preserved, due to the oil used to prevent re-absorption of water.

*(20) The cost of meter repairs may be reduced, and their life extended.

(21) Larger returns from the gas made, due to a reduction in the number of meters registering slow.

(22) Possibility of using smaller service pipes, since without dehydration a larger margin must be given to allow for the gradual blockage due to corrosion and other deposits.

(23) Where waterless holders are used, the danger due to entrainment of water in the tar seal is absent in the case of dehydrated gas, and, in cold weather, formation of ice and resultant blockage are thereby prevented.

Many of these advantages are already definitely reported as being gained, and these are marked with an asterisk. In many cases it is to be anticipated that the advantages specified in the individual answers to the questionnaire would have been more numerous had the dehydration system been working longer.

EXTENT TO WHICH DEHYDRATION SHOULD BE CARRIED OUT.

Under British conditions, it suffices for the dew-point of the gas to be reduced to 45° Fahr. in summer and to 35° Fahr. in winter, though plants are generally constructed of a capacity sufficient to enable the dew-points to be reduced to 40° and 30° Fahr. in summer and winter respectively.

There is no need to keep to these conditions if weather conditions are especially favourable, and, in fact, the degree of dehydration can be fixed from observations of the temperature of that part of the district in which the gas temperature is the lowest. By a weekly observation of the chart of a recording thermometer, the dew-point for the forthcoming week can be fixed at 5° Fahr. below the minimum temperature recorded, to ensure a reasonable margin of safety. It has been found that in autumn, and in the early winter, the gas temperature in the mains is higher than the atmospheric temperature, whereas in spring and summer the reverse is generally the case.

DISADVANTAGES OF PARTIAL DEHYDRATION OF GAS.

The disadvantages which may be regarded as being attributable to the dehydration process are as follows:

1. *Gas-Making Becomes More Complicated.*

It cannot be denied that every additional process to which the gas is subjected on its way from the retorts to the holder represents an increase in the complexity of the operation of gas production. As regards dehydration, however, the simplicity and ease of control of the operation are such that the adoption of a dehydration system cannot strictly be regarded as a disadvantage, the more so since the process enables so many advantages to be realized.

2. *Gas-Making Becomes More Expensive.*

Any additional process to which the gas is subjected increases the cost of gas into the holder. In the case of partial dehydration, however, the extra cost of treatment is more than regained by the direct and indirect savings resulting from the process.

3. *The Revenue from Gas Sales is Decreased.*

Assuming that gas is sold on the basis of a declared calorific value at 30 in. and 60° Fahr. saturated, and is partially dehydrated and subsequently measured in a dry meter at the consumer's premises, the consumer will be supplied with more than one therm for each therm charged.

The loss, though present, is not a large one, as will be seen from the following example, based on the following assumptions for a particular period of the year:—

Basis—1000 C.Ft. at 60° Fahr., 30 In. Saturated.	Without Dehydration.	With Dehydration.
	° Fahr.	° Fahr.
Dew-point of gas *ex* works	60	30
Lowest temperature reached in mains .	46	46
Temperature at consumer's meter . .	60	60

Without dehydration—
1000 c.ft. at 60° Fahr., 30 in. saturated, become
966 c.ft. at 46° Fahr., 30 in. saturated in the mains, and become
993 c.ft. at the consumer's dry meter at 60° Fahr.

With dehydration—
1000 c.ft. at 60° Fahr., 30 in. saturated, become
988 c.ft. at 60° Fahr., 30 in. with dew-point of 30° Fahr., and become
988 c.ft. at the consumer's dry meter at 60° Fahr.

The difference in the volume measured at the consumer's meter is thus only 0·5 per cent. Under the yearly average conditions of distribution the difference would be less than this.

Small as this difference is, there is no reason why it should be borne by the undertaking. It is satisfactory to note that a clause has been modified in the Gas Regulation Act (1920) by the Gas Undertakings Act (1929), which gives the Gas Referees power to take into account the effect of dehydration. The modified clause reads as follows, the recent modification being shown in italics:—

> The calorific value of gas means, for the purposes of this Act, the number of British Thermal Units (gross) produced by the combustion of one cubic foot of the gas measured at sixty degrees Fahrenheit under a pressure of thirty inches of mercury and (*except as otherwise prescribed by the Gas Referees*) saturated with water vapour.

In this connection it may be noted that the Gas Light and Coke Company's Act contains a special clause relating to the testing of dehydrated gas. The clause in question runs:—

> The calorific value of gas means, for the purposes of this Act, the number of British Thermal Units (gross) produced by the combustion of one cubic foot of the gas measured at sixty degrees Fahrenheit under a pressure of thirty inches of mercury *and containing such proportion (if any) of water vapour content as is contained in the gas as supplied to consumers.*

4. *Troubles Due to Rust.*

Due to the mains becoming dried out, rust and other corrosion products previously present may become loose, and be carried forward by the gas stream. When the dehydration system first came into use, it was feared that such troubles might be serious, but it is generally found that this is not the case. It is standard practice to minimize the trouble by oil atomization into the gas, and in the case of new service pipes it is advantageous to coat the pipes with oil or with a red oxide paint. An internal coating applied to new services is advantageous, also, in preventing formation of iron carbonyl which would otherwise occur. In this connection the remarks made by J. T. Spencer at the annual meeting of the Western Junior Gas Association on April 26, 1930, are of interest:

> This internal coating of our service pipes and steel tubes is also a protection against the formation of iron carbonyl which we have experienced in a few cases of service pipes having a small flow of gas through them. The trouble was confined to our street lamps, particularly those which are centrally suspended and have a long length of horizontal supply pipe. These lamps reduce at midnight from eight-burners to two-burners, and favourable conditions were probably produced from midnight until sunrise. The effect was in some cases to form a red stain or film around the mantles near the mantle ring, in other cases fine particles of iron rust dropped inside the mantles. Iron rust was also found in the nozzles and superheaters. The light from the mantles was very much reduced, and they had to be immediately replaced.

With regard to the liberation of rust from mains dried out as a result of partial dehydration of the gas, the following experience at Portsmouth quoted by Whitehead ("GAS JOURNAL," **187**, 133, 1929) is of interest:—

> At a gas velocity up to 10 ft. per second, particles of rust whose size is less than 200 mesh can be carried to the extent of 0·1 gramme per 100 c.ft. There is no evidence that this dust has any harmful effect on meters.
>
> It appears that a trace of oil in the gas has a considerable effect in preventing the fine rust being picked up.
>
> The samples of rust from services, and from meters, which were received were too coarse in grading to have been carried forward by the gas, particularly as its velocity in the service is probably lower than either before or after that point.

In the case of one undertaking (Neath) precautions are taken to minimize troubles due to rust, as will be evident from the following quotation from a reply to the questionnaire:—

> The few complaints which now come in are simply rust complaints, and as the rust is now perfectly dry the service pipes are very easily cleaned, and I do not expect any recurrence of rust complaints when these services are dealt with in future. I am, however, taking the precaution of disconnecting the services at the main and cleaning through from the house outwards, so that none of this loose rust is blown back into the main where it might cause trouble.

The experience of the Gas Light and Coke Company at Staines has been as follows :—

> Complaints of rust deposits averaging 60 per annum have increased to 120. This is probably due to loose material previously held by the moisture in the mains coming forward, and is expected to be temporary.

5. *Reabsorption of Water in the Holders. Necessity for Oil Filming.*

In cases in which, as is usual, the dehydration plant is situated at the inlet of the gasholders, absorption of water by the partially dehydrated gas would occur in the holders when these are not of the waterless type, and the effects of dehydration would thus be nullified. Water absorption is minimized by the maintenance of an oil film $\frac{1}{4}$ in. to $\frac{3}{8}$ in. in thickness on the surface of the water in the holder.

Even so, some increase in the dew-point of the partially dehydrated gas occurs, the more so when, as is often the case, timber trusses and framing are present inside the holder. Any timber present will have become saturated with water during the use of the holder prior to the introduction of dehydration, and the water is continuously absorbed by the dehydrated gas due to the latter being unsaturated as regards moisture content. The dew-point may in consequence of this increase by about 2° to 3° Fahr. in winter and 4° to 5° Fahr. in summer. The effect on the dew-point due to the water present in the wood gradually diminishes, but there remains a slight effect due to capillary attraction of the water from the tank below the oil film and up through the pores of the timber, and an effect due to the constant rising and falling of the holder plates out of and into the tank. The effect on the dew-point is small when the holders are worked steadily, but with conditions equivalent to working "in and out" of the holder, under which the bell rises and falls fairly rapidly, the dew-point may rise by as much as 4° to 9° Fahr. (Whitehead, *loc. cit.*).

The reduction in dew-point normally attained with a dehydration process provides an ample margin to render such re-absorption of water as may occur of little significance.

The fact that oil filming is necessary in order to minimize re-absorption of water is not really a disadvantage, since the interior of the holder is thereby protected against corrosion, and maintenance costs are thus considerably reduced.

Normally, the oil used for filming should suffer little wastage, and a figure showing that 2 per cent. of the original quantity used is required to be added every twelve months is quoted by Collins ("GAS JOURNAL," **189**, 760, 1930).

In cases in which the oil has disappeared from the holders comparatively rapidly, the cause has probably been a blowing of the holders, with consequent displacement of the oil from the inside to the outside of the holder.

An external oil film is also nowadays often maintained with a view to the protection of the outside of the holder against corrosion, and painting costs are thereby at the same time reduced.

Collins (*loc. cit.*) has specified the following properties which a satisfactory filming oil should exhibit :—

(1) Freedom from sulphur and inorganic acids.
(2) A relatively low freezing-point.
(3) Sufficiently high vaporizing-point to obviate evaporation.
(4) Sufficiently adherent properties to ensure the film remaining continuous when exposed to the weather or submerged in the tank for extended periods.
(5) Freedom from the liability to oxidation, which would result in the oil becoming gummy and laden with sludge.
(6) Ability to separate rapidly when mixed with water.
(7) Freedom from any solvent action on existing paintwork.

In the case of an oil capable of emulsifying with water, there will be a possibility of re-absorption of water by the gas. If ordinary gas oil be used for filming, the oil may tend to destroy the tape between the riveting of the plates, and thereby cause slight leakage. (An instance of this was encountered at Blackpool.) By use of an oil of suitable quality such troubles should be non-existent.

6. *Gum Formation.*

In some cases deposits of gum have been found in governors and elsewhere as a result of the introduction of partial dehydration. Spencer, in his recent lecture, reported as follows :—

> Some little trouble has been experienced with gummy deposits on the valves of our station governors which prevented the valves from opening freely after times of minimum demand. A few instances of similar deposits in the injectors of gas fires were reported. Gummy deposits have been reported from some towns where a percentage of carburetted water gas is distributed, and have been found to consist of polymerized styrene and indene obtained from the gas oil used. In our case these deposits were not met with prior to the installation of the gas drying plant, so it is reasonable to assume that the oil washing for naphthalene extraction or possibly the film of oil on the water in the holders is the source of the trouble.

7. *Loss of Water from Wet Meters.*

Where wet meters are in use in the consumer's premises, the effect of the passage of partially dehydrated gas is to evaporate water from the meters, which therefore require periodical replenishment. Alternative methods of countering this trouble have been proposed by Harris, and consist in the use of a solution of glycerin or of calcium chloride in the meters, or of a mixture of paraffin and anthracene oil having a specific gravity approximately equal to that of water.

8. *Wastage of the Drying Agent Due to Reaction with Constituents of the Gas.*

In the case of the calcium chloride process, under conditions in which ammonia is present in the gas calcium carbonate is formed by interaction between ammonium carbonate, formed by combination of ammonia and some of the carbon dioxide contained in the gas, and the calcium chloride. The calcium carbonate is then deposited on the evaporator, and requires to be removed periodically. This is, however, a simple operation. In the case of installations for the treatment of gas under pressure, filters would be provided for removing suspended matter from the liquor leaving the dehydration vessel.

9. *Corrosion Due to the Action of the Drying Agent.*

Fears that corrosion might be caused in the main at the outlet of the drying plant, due to the carrying-forward of a mist of calcium chloride solution, have proved groundless.

The question of the possible and actual disadvantages attaching to the use of dehydration processes has been treated somewhat fully, and it might on this account be imagined that they are a serious drawback to the dehydration system. The general consensus of opinion is, however, the justifiable one that the advantages far outweigh the disadvantages.

POSITION OF THE DEHYDRATION PLANT.

The dehydration plant may be situated in a position in the gas system convenient for local conditions. It is sometimes installed at the inlet to the station meters, more generally at the inlet to the holders, and occasionally at the outlet of the holders.

Where dry, such as "Connersville," station meters are in use, there is a great deal to be said for installing the dehydration plant at the meter inlet, since in that case the volume of the treated gas is indicated. This is not, however, possible where wet meters are employed unless the water in the meters is covered with a film of oil; otherwise, of course, the results of dehydration would be nullified.

In undertakings in which the daily load is not subjected to wide variations throughout the year, dehydration after the holder is not a drawback, but where the daily demands fluctuate rapidly a smaller dehydration plant is required if dehydration is carried out at the inlet to the holders, since a plant at the outlet would require to be larger to enable it to cope with peak loads.

The pressure drop through the dehydration plant is often as low as two or three tenths of an inch or even less, but in the larger plants it is generally much higher. In an extreme case a pressure drop amounting to $4\frac{1}{2}$ in.

prevails in the dehydration plant, and a similar drop in the naphthalene scrubber.

RANGE OF APPLICABILITY OF DEHYDRATION PLANTS.

Information has been received from plants with a daily make ranging from 0·1 million to 13 millions. The process of dehydration is thus equally applicable, whatever the size of the undertaking.

In the case of most of the undertakings which have furnished information, high-pressure gas is not distributed. In a few cases, some high-pressure gas is distributed, or part of the make may be boosted for use as feeder for distribution mains. The highest pressure referred to was 25 lbs. per sq. in.

DEHYDRATION OF GAS BY REFRIGERATION.

The dew-point of gas may be lowered by refrigeration, this being effected by scrubbing the gas with a spray of chilled water or brine. The water or brine is then re-cooled by means of a refrigerating plant, and re-circulated. Any form of refrigerating plant may be employed—*e.g.*, machines employing ammonia, sulphur dioxide, carbon dioxide, or dichlorethylene.

Such a system is uneconomical if applied to the treatment of less than about 6,000,000 c.ft. of gas per day, but for very large installations should be both feasible and capable of competing with dehydration by use of a dehydrating agent.

Naphthalene would be precipitated from the gas during cooling, and this would necessitate filtering the cooling medium.

DEHYDRATION OF GAS BY METHODS INVOLVING COMPRESSION.

In connection with alterations of pressure in the case of a saturated gas, it must be borne in mind that compression raises the temperature and renders the gas unsaturated, whereas expansion cools the gas and renders it supersaturated, water being deposited.

If a saturated gas is compressed, and is then cooled to its original temperature, water separates out, but the dew-point is unaltered. The weight of water present per unit mass of the dry gas has been reduced, but the compressed gas is just as liable to deposit water in the mains as would be a saturated gas distributed under normal pressure.

On the other hand, the pressure drop which the gas suffers in its passage through the mains, and the consequent increase in volume, causes a lowering of the dew-point, and, provided that the temperature of the gas does not drop more rapidly than the dew-point falls, condensation will not occur.

Fig. 2 shows the effect of pressure drop on the dew-point of gas compressed to a gauge pressure of 10 lbs. per sq. in. and a dew-point of 60° Fahr. It will be noted that each successive pressure drop of 1 lb. per sq. in. causes an increasingly larger drop in the dew-point.

It has been pointed out above that compression of the saturated gas to the distribution pressure followed by cooling to the original temperature does not affect the dew-point; hence, if an actual lowering of the dew-point is required, a more complicated method is required.

A possible method of effecting the dehydration is as follows. The gas is compressed to a higher pressure than the distribution pressure, and part of the temperature rise consequent on compression is reduced by cooling, with separation of water. The gas is then allowed to expand to the distribution pressure. The cooling may be effected by means of water sprays.

Such a method would be more expensive than dehydration by use of a dehydrating agent. Hence, if dehydration to a low dew-point is required for a gas which is to be distributed under pressure, a dehydrating agent should first be made use of, and the dehydrated gas may then be compressed and cooled, or preferably the dehydration may be effected in a pressure plant, the gas being first compressed and cooled.

If the first method is employed, dehydration must be carried out to a lower dew-point than is the case when distribution occurs at the normal pressure, since the subsequent compression has the effect of raising the dew-point, this being the converse of the phenomenon discussed above in connection with the effect of pressure drop on the dew-point.

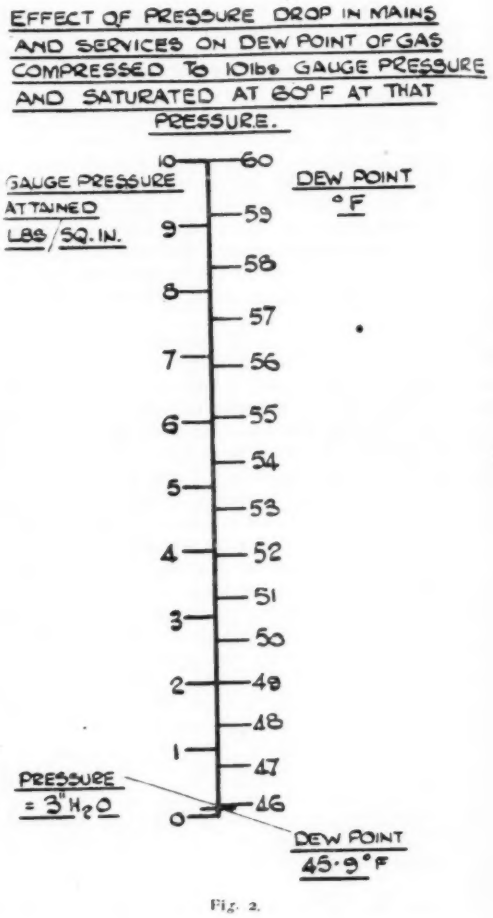
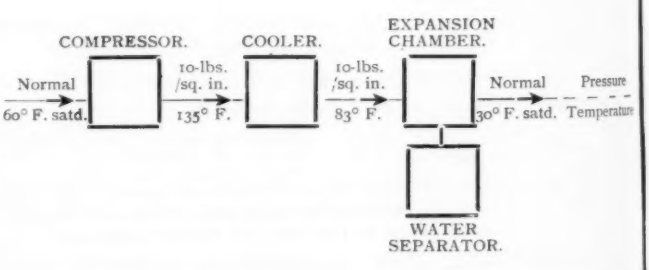


Fig. 2.

Fig. 3, by Sperr (Transactions of the American Gas Association, 1926), shows the dew-point to which the gas must be dehydrated in order that the compressed gas at a specified pressure may have a dew-point of 30° Fahr. It will be seen that, if the gas is to be compressed to a gauge pressure of 50 lbs. per sq. in., the dew-point of the uncompressed gas would have to be brought to a temperature as low as 0° Fahr. in order that the dew-point after compression may be 30° Fahr. Such a scheme is not very practicable.

The alternative method of subjecting the *compressed* gas to dehydration by, for example, calcium chloride or glycerin is much more practicable, since the desired dew-point can be attained more readily.

A method for dehydrating gas based on the cooling effect of expansion is illustrated in the following scheme:—



By use of such a process the gas could be delivered at a temperature of 30° Fahr. and a dew-point of 30° Fahr., but, although at its dew-point, the gas would not deposit moisture in the mains, since in passage through them its temperature would rise and the gas would become more and more unsaturated.

The cost of dehydrating gas by a compression process alone is higher than for dehydration by an absorbent; hence such methods do not come into consideration except when the gas is to be distributed under pressure. The

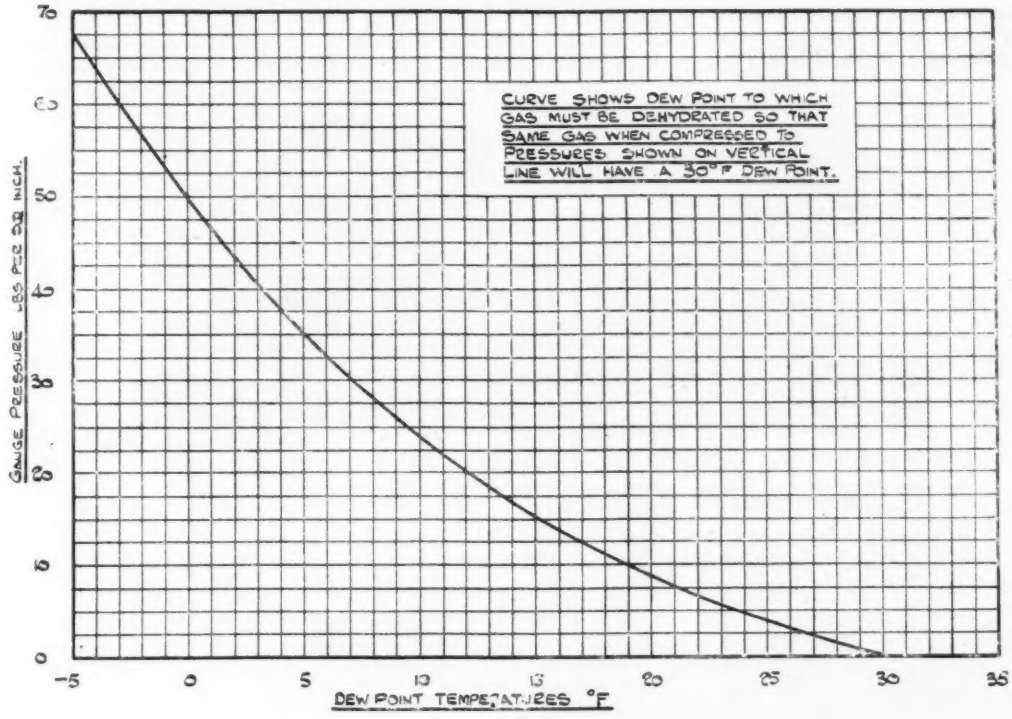

CURVE SHOWS DEW POINT TO WHICH GAS MUST BE DEHYDRATED SO THAT SAME GAS WHEN COMPRESSED TO PRESSURES SHOWN ON VERTICAL LINE WILL HAVE A 30° F DEW POINT.
GAUGE PRESSURE LBS PER SQ INCH.
DEW POINT TEMPERATURES °F

FIG. 3.

success of the operation depends also, in a high degree, on the temperature of the available cooling water, and with increasing temperature of the cooling water the costs are raised to a disproportionately large extent.

THE RELATIVE DRYING POWERS OF CALCIUM CHLORIDE AND GLYCERIN.

Fig. 4, representing vapour pressure data for water and for solutions of calcium chloride and of crude glycerin of varying strengths, has been prepared by Dr. Colman.

The curves show the vapour pressures of the various solutions and of water over a range of temperature from 50° to 86° Fahr. The relative humidity of gas in equilibrium with a particular solution at a particular temperature is obtained by dividing the vapour pressure of the solution by that of water for the temperature in question. It will be found that the relative humidity in the case of any of the solutions is affected but very slightly with the temperature. Thus in the case of a 40 per cent. solution of calcium chloride, relative humidities are as follows :—

Temperature.	Vapour Pressure of Water.	Vapour Pressure of Solution.	Relative Humidity.
° Fahr.	Mm.	Mm.	Per Cent.
52	10·0	4·0	40
66	16·5	6·6	40
84	30·0	12·0	40

The figure shows also that the curves for the glycerin solutions and the calcium chloride solutions are of such a form that it is possible to match very closely a glycerin curve by a calcium chloride curve. This implies that the two media will be equally efficient as dehydrating agents provided that the working strengths of the solutions are kept within the appropriate limits, and provided also that the limits are such that no working difficulties are encountered in the use of the solutions. Actually such difficulties do not manifest themselves, since with either agent it is possible to work with a solution having both the necessary concentration and ease of handling.

THE CALCIUM CHLORIDE PROCESS.

In this process, the drying agent is a solution of calcium chloride maintained at a suitable concentration. During absorption of the water vapour from the gas, the solution becomes diluted, and at the same time its temperature increases. The diluted liquid passes to a storage sump,

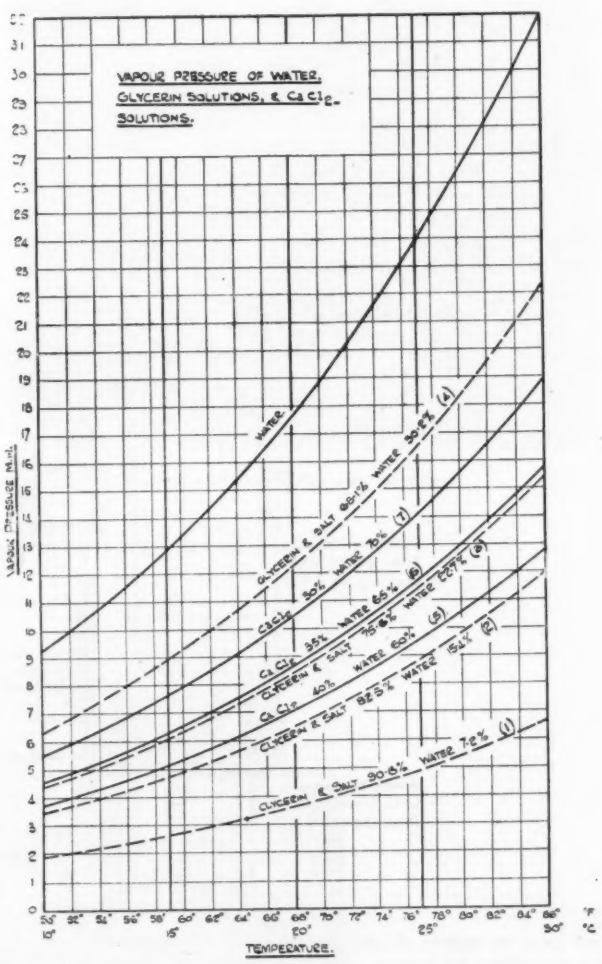

VAPOUR PRESSURE OF WATER, GLYCERIN SOLUTIONS, & Ca Cl2 SOLUTIONS.
VAPOUR PRESSURE M.M.
WATER.
GLYCERIN & SALT 69·1% WATER 30·9% (4)
Ca Cl2 30% WATER 70% (7)
Ca Cl2 35% WATER 65% (6)
GLYCERIN & SALT 76·8% WATER 23·2% (3)
Ca Cl2 40% WATER 60% (5)
GLYCERIN & SALT 82·5% WATER 17·5% (2)
GLYCERIN & SALT 90·6% WATER 9·4% (1)
TEMPERATURE.

Fig. 4.

a small proportion, approximately 7·5 per cent., being diverted to a steam-heated concentrator situated over the

sump. Liquor from the sump is brought into the circuit again *via* a tubular cooler, cooled externally by cold water.

A flow diagram is shown in Figs. 5 and 6, and photographs of installations are shown in Figs. 7, 8, 9, 10, and 11.

to avoid tendency towards crystallization in the feed pipe to the washer. The concentrations indicated represent solutions containing respectively 40 per cent. and 38 per cent. by weight of anhydrous calcium chloride. Additional precautions during cold weather are the fitting of

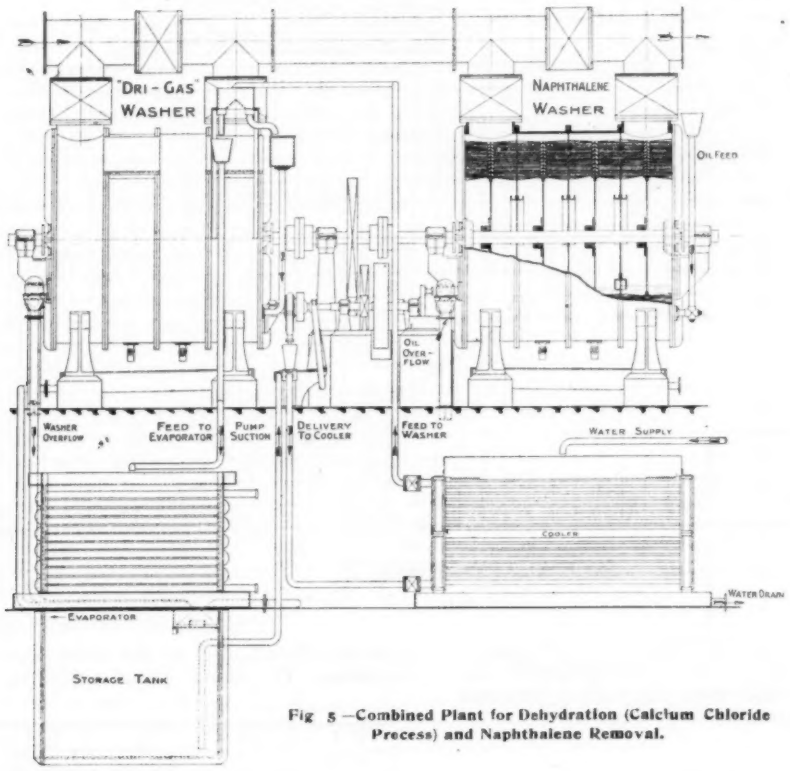


Fig 5.—Combined Plant for Dehydration (Calcium Chloride Process) and Naphthalene Removal.

The water may be absorbed from the gas by slow-moving rotary scrubbers of the brush type, or by tower scrubbers in which the upward current of the gas is in contact with a descending spray of the drying agent. In each case the gas and liquor flow is counter-current.

When rotary scrubbers are employed they are generally worked from an engine driving at the same time the naphthalene scrubbers by means of a common shaft.

The usual strength in which the calcium chloride is used is that of a solution of 80° Tw. (summer) or 76° Tw. (winter), a lower concentration being employed in winter

a 3-in. overflow from the chloride feed head back to the storage tank, and the shielding of the concentrator and coolers from wind.

Table 2 shows the relationship between the strength and specific gravity of solutions of calcium chloride saturated at various temperatures, and Fig. 12 the relationship be-

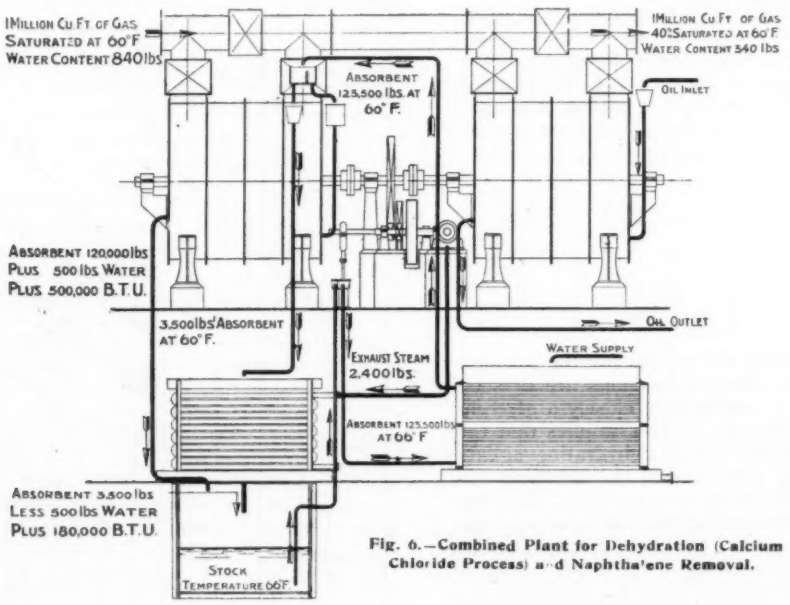

1 MILLION CU FT OF GAS SATURATED AT 60° F WATER CONTENT 840 lbs
1 MILLION CU FT OF GAS 40% SATURATED AT 60° F WATER CONTENT 340 lbs
ABSORBENT 123,500 lbs. AT 60° F.
OIL INLET
ABSORBENT 120000 lbs PLUS 500 lbs WATER PLUS 500,000 B.T.U.
3,500 lbs ABSORBENT AT 60° F.
OIL OUTLET
EXHAUST STEAM 2,400 lbs.
WATER SUPPLY
ABSORBENT 123,500 lbs AT 66° F
ABSORBENT 3,500 lbs LESS 500 lbs WATER PLUS 180,000 B.T.U.
STOCK TEMPERATURE 66° F.

Fig. 6.—Combined Plant for Dehydration (Calcium Chloride Process) and Naphthalene Removal.

tween the vapour pressure of water and of solutions of calcium chloride and temperature. Vapour pressures are expressed in terms of the equivalent content of water vapour in grains per c.ft. (1 grain of water vapour per c.ft. = 14·3 gallons of water per million c.ft.). The

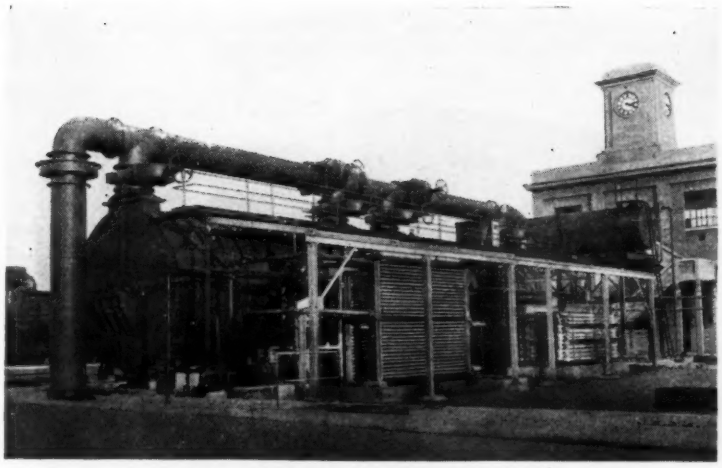


Fig. 7.—Dehydration Plant at Bournemouth.

TABLE 2.—*Solubility and Specific Gravities of Saturated Solutions of Calcium Chloride.*

Temp. ° Fahr.	Lbs. Calcium Chloride per Gallon of Water.	Specific Gravity Deg. Tw. at 60° Fahr. (Approx.).
32	5·95	74·5
35	6·05	75·5
40	6·15	76·0
45	6·30	77·5
50	6·50	79·0
55	6·70	81·0
60	6·95	83·0
65	7·25	85·5
70	7·65	89·0
75	8·15	93·5
80	8·85	99·5
85	9·75	108·0

figure shows also the water content of gas in equilibrium with the various solutions at different temperatures.

It will be apparent that drying is influenced beneficially by a high concentration of the calcium chloride and by a low temperature. In summer, when river water or other cooling water available is at too high a temperature to enable effective cooling of the solution to be possible, it is often advantageous to make use of water drawn from the tank of a gasholder. In some cases this water is obtained by gravity from an elevated holder tank, and after passage over the coolers is passed to a second holder tank at a lower level, whence it is returned to the first holder by means of a pump.

In winter, on the other hand, when the cooling water is very cold, air cooling may be used to replace water cooling.

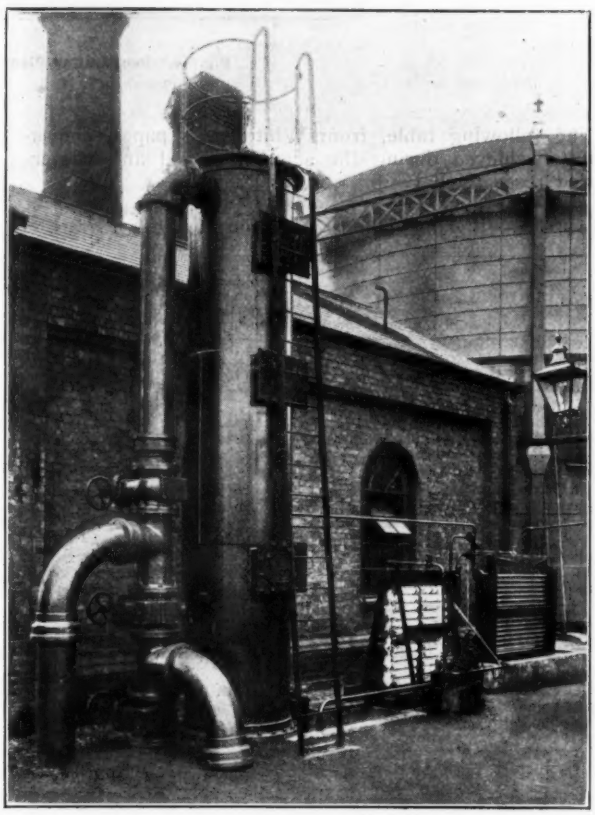


Fig. 8.—Dehydration Plant at Ware.

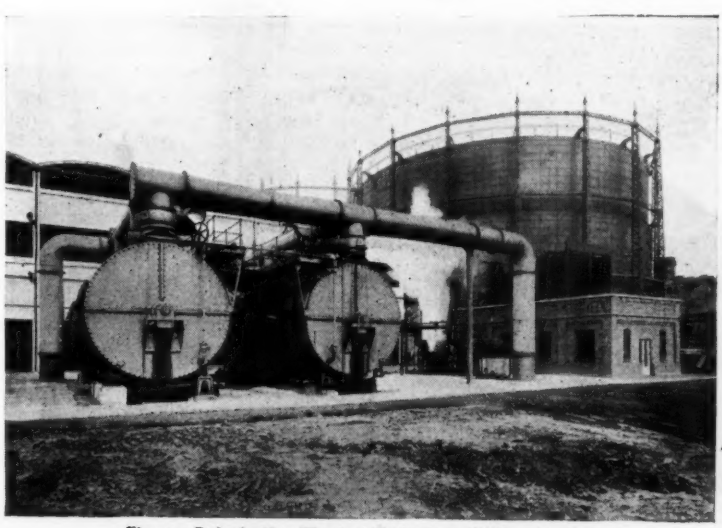


Fig. 9.—Dehydration Plant at Tottenham (Willoughby Lane).

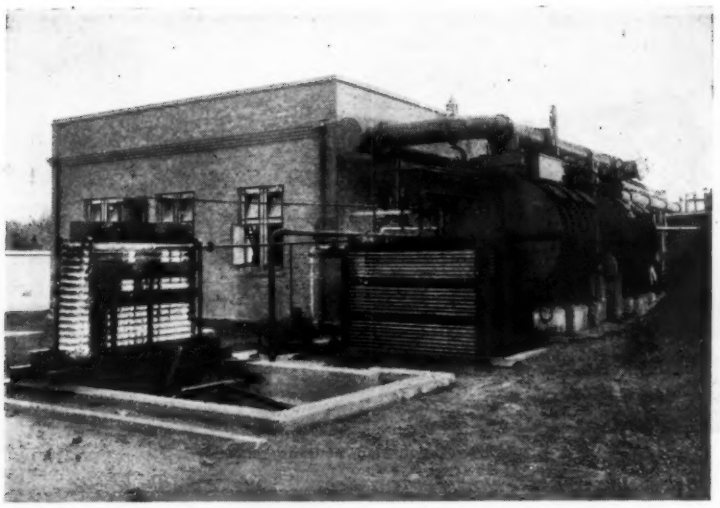


Fig. 10.—Dehydration Plant at Ponder's End, Tottenham.

The following table, from Whitehead's paper, shows results achieved during the summer period and winter period respectively :

TABLE 3.—*Working Details of Calcium Chloride Process.*

—	Summer and Autumn. May-October (Inclusive).	Winter and Spring. November-April (Inclusive.).
Gas treated—		
Millions of c.ft. per 24 hours	4·186	5·545
Liquor flow—		
Through washer, gallons per hour	1500	1471
Over concentrator, gallons per hour	112	96
Liquor strength, ° Tw.—		
Entering washer	78·5	76·7
Leaving washer	76·8	75·5
Storage sump	77·6	76·0
Temperatures, ° Fahr.—		
Air	58·7	40·7
Cooling water	56·0	49·0
Liquor entering washer	64·7	52·5
Liquor leaving washer	74·5	59·5
Liquor in storage sump	74·2	59·8
Dew point of gas, ° Fahr.—		
Inlet washer	61·8	46·2
Inlet holder	37·6	30·0
Outlet holder	40·5	33·8

These results are typical in that they show :

1. A high reduction of the dew-point in summer, the reduction being of the order of 24° Fahr.
2. A lower reduction of the dew-point in winter, the reduction being approximately 16° Fahr.
3. Re-absorption of water in the holder with a consequent rise of 3° to 4° Fahr. in the dew-point.
4. A reduction of the dew-point to a lower value in the winter than in the summer, the difference being approximately 8° Fahr., and representing general experience.

It is to be noted that in cases in which the summer demand for gas is very much less than the winter load, the gas may be reduced to a lower dew-point in the summer than in the winter (*e.g.*, Colne). This, however, is an exceptional case.

The wastage of calcium chloride averages about 10 lbs. per million c.ft. of gas handled.

THE GLYCERIN PROCESS.

This process has not been adopted to the same extent as has the calcium chloride process, as there is only one plant in operation in this country.

The essential features are the same as for the calcium chloride process, save that concentration of the diluted

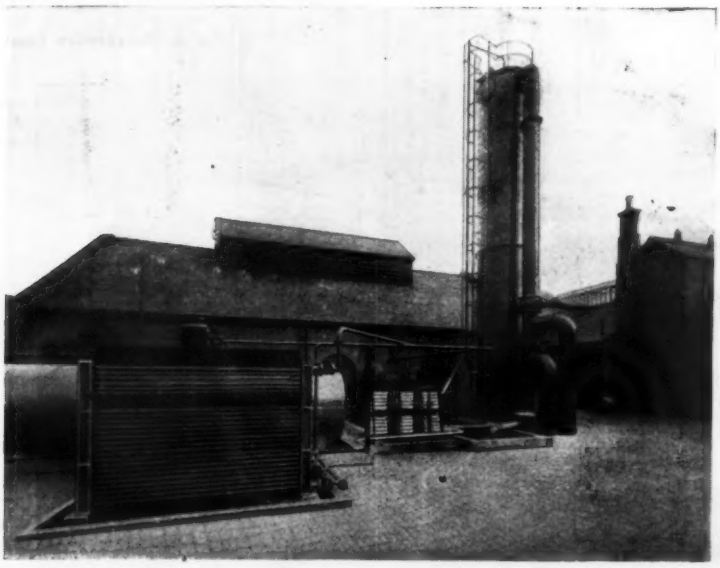


Fig. 11.—Dehydration Plant at Shrewsbury.

desiccating agent must be carried out in a vacuum still. Figs. 13 and 14 show a photograph and flow diagram of the plant. A crude glycerin is used, containing salt as the chief impurity.

For successful working, the water content should not exceed 15 per cent. by weight at the inlet to the drying plant, and may be allowed to rise to 22·5 per cent. or more at the outlet. If much less than 15 per cent. of water is present, the glycerin is too viscous and is liable to froth with gas. Also, evaporation losses during concentration would be too heavy, since glycerin is readily volatile with steam at high concentrations of glycerin, and sensibly volatile at lower concentrations.

In the plant for which details are available, the evaporator is not worked continuously, there being two tanks, one an overhead feed tank for the concentrated glycerin, and one a low-level receiving tank for the spent glycerin. The evaporator is put into action when the feed tank is empty, and delivers the concentrated glycerin to the feed tank *via* a pump and cooler. The evaporator loss is stated not to exceed one-quarter of 1 per cent. of the entering glycerin. During summer the evaporator is worked eight hours per day, and during the winter four hours per day.

The loss of drying agent is given as approximately 5 lbs. per 1,000,000 c.ft. of gas treated, which with glycerin at £35 per ton represents 17d. per million.

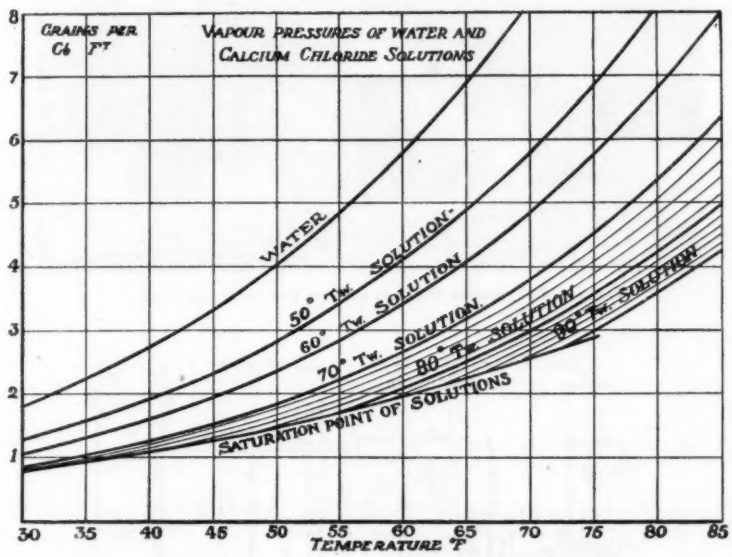


Fig. 12.

While this loss of drying agent represents a greater cost than is experienced in the case of calcium chloride plants, it is nevertheless not of sufficient magnitude to warrant undue consideration being given to this aspect.

COST OF PARTIAL DEHYDRATION.

From the data which are available, it is not possible to form an exact estimate of the relationship between the size of the plant and the cost of the process, since local conditions vary so widely. Thus in some cases no account is taken of the cost of cooling water, since an inclusive charge is made for the whole water requirements of the works, whereas in other undertakings town water is used. Similarly in the case of steam, sufficient exhaust steam may be available for the working of the evaporator; and the additional power required for the dehydration scrubber, when a naphthalene scrubber is worked from the same engine, is less than in cases where dehydration only is practised. In some cases it has happened that the two halves of a naphthalene scrubber were formerly both in use; but as a result of the increased efficiency of naphthalene scrubbers in absence of water, it has become possible to employ the first half of the scrubber as the dehydration unit, and the second half as the naphthalene extraction unit without impairing the efficiency of naphthalene removal.

As regards labour, also, figures are generally not available, since very often the work of running the dehydration plant is undertaken merely as an additional duty, since the process requires very little attention beyond making sure that the plant is functioning, and that the solution is of the correct strength. In the case of a small undertaking, on the assumption that the attention required is only half-an-hour per day, the cost of labour for a plant having a daily capacity of 100,000 c.ft. would be as much as 7s. 6d. per million; and though this charge might not actually be incurred, since the work would be merely an incidental duty, a charge for labour must be debited to the process.

Table 4 has been prepared with a view to showing approximately the total costs of the calcium chloride process, and has been based on the information contained in the replies to the questionnaire. Labour has been reckoned at 1s. 6d. per day for plants having a daily capacity up to 3 million c.ft. per day, and at 6d. per million for larger plants.

Other items taken into account are as follows :—

Capital charges, depreciation, and maintenance	12½ per cent. on capital cost
Steam (3000 lbs. per million c.ft.)	1s. 6d. per 1000 lbs.
Water (6000 galls. per million c.ft.)	10d. per 1000 galls.
Calcium chloride (wastage 10 lbs. per million c.ft.)	£5 10s. per ton
Lubricating oil, stores, &c.	1s. per million c.ft.

The total running costs, exclusive of labour and capital charges, are thus taken as 11s. per million c.ft.

The capital costs include foundations and erection.

TABLE 4.—*Cost of Calcium Chloride Process.*

Average Daily Throughput.	Capital Cost.*	Capital Cost per Million per Day.	Capital, Depreciation, and Maintenance per Million per Day at 12½ per Cent.	Ditto per Million Treated.	Labour and Operating Costs per Million Treated.	Total Costs per Million Treated.
Millions.	£	£	Pence.	Pence.	Pence.	Pence.
0·1	500	5000	150,000	410	312	722
0·5	1500	3000	90,000	246	168	414
1·0	2000	2000	60,000	164	150	314
1·5	2300	1550	46,500	127	144	271
2	2500	1250	37,500	102	141	241
3	3000	1000	30,000	82	138	220
Above 3	1000 per million	1000	30,000	82	138	220

* This includes provision for a capacity adequate for seasonal peak loads.

The range of costs is thus from 0·22d. to 0·72d. per 1000 c.ft., or 0·044d. to 0·144d. per therm (of 500 B.Th.U. gas), depending on the size of the installation. It will be evident that the figures can be made lower if labour costs be neglected, or if water at an exceptionally low

charge is available. In any case the costs are sufficiently low to render the process advantageous.

FINANCIAL SAVINGS CONSEQUENT ON DEHYDRATION.

It is difficult to give a close estimate of the savings realized as a result of partial dehydration. The following extracts from replies to the questionnaire give some indications, but local conditions vary very widely :—

1. *Plant with Average Daily Treatment of* 0·11 *Million.* (*Kelso.*)

"Saving of time and labour of gasfitter and absence of trouble to the consumer. Less corrosion of mains and services and longer life of meters.

"The gross savings in distribution costs per million c.ft. I estimate at 7s. 6d."

2. *Plant with Average Daily Treatment of* 0·65 *Million.* (*Neath.*)

"In nine months the saving in labour and material on the district due to the dehydration plant has been £209 18s. Freedom from syphon pumping, service complaints, and rust formation. The plant was put down as a combined dehydration and naphthalene plant, and as such the effect on the distribution work and expenses of same has been to reduce this very considerably, the combined plant having saved the department in nine months approximately £400 in actual wages costs after allowing for all the expenses, labour, steam, and material essential to running the plant.

"The gross saving in costs for the nine months is £524 on a make of 165 million c.ft., which equals £3 3s. per million c.ft. This includes the first three months' working of the plant, when, of course, complaints due to water, rust, and naphthalene were still present, but in a diminishing quantity."

3. *Plant with Average Daily Treatment of* 0·4 *Million.* (*Bexhill.*)

"*Services Cleared.*

1929—July (dehydration started)		1154
	August	729
	September	496
	October	382
	November	308
	December	200
1930—January		140
	February	240*
	March 1–21	69

* New calcium chloride added this month.

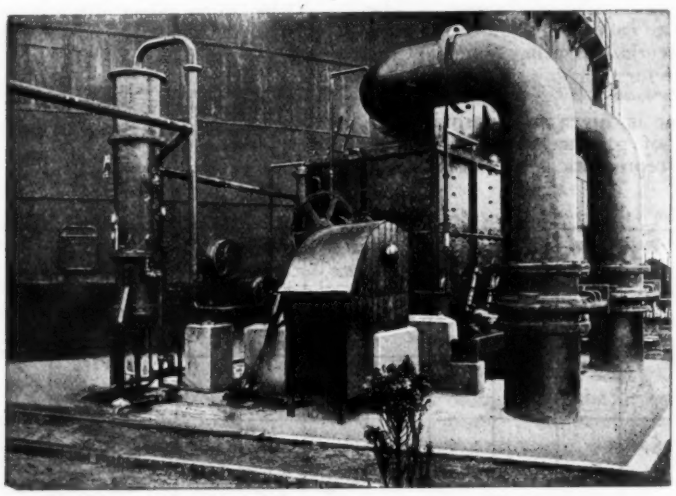


Fig. 13.—Dehydration Plant at Colwyn Bay (Glycerin Process).

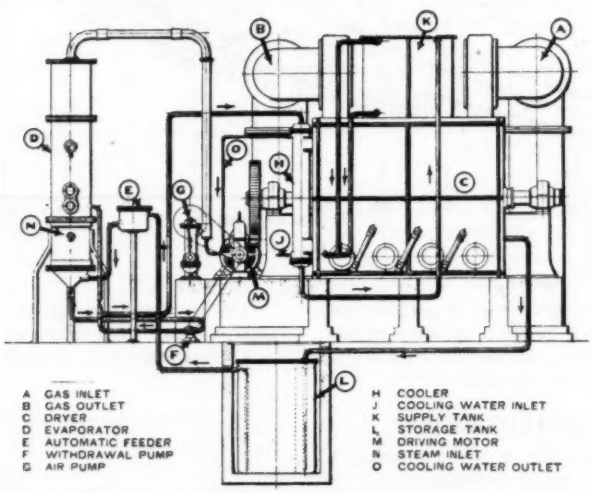


Fig. 14.—Dehydration Plant (Glycerin Process).

"In addition to saving represented by diminution in number of services now requiring to be cleared, solvent naphtha was formerly used in a vaporizer, the annual cost of which amounted to over £200."

4. *Plant with Average Daily Treatment of* 3·5 *Millions.* (*Blackpool.*)

"We obtained a distinct advantage during the period of severe weather we had in February, 1929. We were not troubled with frozen services, and the complaints received were negligible.

"The cost of syphon pumping in the district has been entirely eliminated.

"Further, an important item as far as we are concerned is the question of better service, on which a monetary

TABLE 5.—*Partial Dehydration of Gas. Extracts from Replies to Questionnaires Relating to 24 Plants.*

[Other Details are Referred to in the Text.]

—	Gas Treated Daily, Millions of C.Ft.						Nature of Gas Treated.	Position of Plant. I = Inlet. O = Outlet. M = Meter. H = Holder.	Pressure Drop Across Plant. Tenths, W.G.	Type of Scrubber.	Dew Point Attained, ° Fahr.		Frequency of Regeneration.	Age of Plant to May, 1930. Months.	Meters Used in District.	Temperature of Gas ex Works, ° Fahr. (1929 or 1929-30).	
	Max.	Min.	Annual.	Summer.	Winter.	Rated.					Summer.	Winter.				Summer.	Winter.
Bexhill	..	..	0·4	..	..	..	17 per cent. C.W.G.	IM	2	..	40–45	30–35	Continuous	10	Dry	73†	52†
Blackpool	..	..	3·5	..	..	..	Up to 20 per cent. W.G.	IM	15	Brush	40	31	Continuous, save winter	24	Majority dry	66	57
Bournemouth	12·5	..	..	6·0	9·5	10·0	33 per cent. W.G.	IH	45	Brush	40	31	Continuous	31	Dry except lamps	60	54
Brighouse	..	..	0·55	..	..	..	Straight	IH	3	..	40	29	,,	10	Almost all dry	68	52
Bristol	..	..	4·0	..	..	..	Vertical retort	IH	8	..	43	31	,,	27	Dry	68	52
Cheltenham	2·8	1·2	1·72	..	..	..	H.R. and V.R.	IH	2	..	36	29	,,	24	Dry	..	..
Colne	..	..	..	0·6	1·0	..	Mixed	IM	5	Brush	28–33	About 35	,,	24	Dry	64	52
Derby	..	..	4·3	..	..	..	Mixed H.R., V.R., C.W.G., B.W.G.	IH	16	Brush	44	39	18 hours/day	20	Dry and wet	56‡	48‡
Gas Light and Coke Company (Staines)	..	..	1·0	..	..	..	Mixed	OH	7½	Tower	39	25	6 hours/day	38	Dry save one wet	65	40
Great Yarmouth	0·8	0·3	0·5	..	..	..	Mixed	IH	3	..	38	32	Continuous	22	Dry	61	48
Kelso	..	..	0·11	..	..	..	Coal and Tully gas	IH	Below 1	Tower	44	36	3 hours/day	20	Dry and wet	65	45
Long Eaton	..	..	1·0	..	..	..	Mixed	IH	25	Brush	18	16	Continuous	21	Dry	..	..
Neath	..	..	0·65	..	..	..	Mixed	IM	1	Brush	44	35	,,	12	Dry	64	40
Portsmouth	6·5	4·0	..	..	..	..	Mixed	IH	12	Brush	40	30	,,	32	Almost all dry	..	..
Ramsgate	..	..	0·87	..	..	1·5	0·25 per cent. C.W.G.	IH	5	..	45	35	,,	12	Dry	..	..
Shrewsbury	..	..	0·88	..	..	..	Mixed	OH	½-1½	Tower	*	*	,,	22	Dry, 3 or 4 wet	62	44
Taunton	..	..	0·7	..	..	..	Mixed	IH	3	Brush	37	24	,,	44	Dry	63	45
Tottenham, Willoughby Lane	13·0	8·0	8·25	..	..	16·0	Mixed H.R., V.R., C.W.G.	IH	5	Brush	?	35	,,	8	Dry	..	57
Tottenham, Ponders End	3·0	1·0	1·75	..	..	3·0	Mixed	IH	2½	Brush	?	35	,,	8	Dry	..	57
Tunbridge Wells	..	..	1·6	..	..	..	39 per cent. W.G.	IH	None	Brush	40–45	30–40	8–10 hours/day	26	Dry	..	..
Ware	..	..	..	0·10	0·15	0·25	40 per cent. C.W.G.	OH	Negligible	Tower	?	28–30	Alternate days	7	Dry save one wet	..	..
Weston-super-Mare	1·82	..	1·18	..	..	..	Mixed	IH	1-2	Brush	39	29	4–5 hours/day	33	Dry	66	45
United Steel Companies (Orgreave Bye-Product Coking Plant)	..	..	4·2	..	..	..	Coke oven gas	OH	5-10	Brush	..	..	Continuous	14	Gas supplied in bulk	..	..
Colwyn Bay	..	..	0·6	..	..	..	Vertical retort	OH	2	Brush	40–50	30–40	8 hours/day (summer) 4 hours/day (winter)	19	Dry	75	50

All the plants are employing the calcium chloride process, save Colwyn Bay, which employs glycerin.

* 15-20° below minimum average air temperature, summer.
5-10° ,, ,, ,, ,, ,, ,, winter.

† Temperature taken in laboratory.
‡ Ground temperature on level with mains.

advantage cannot be definitely fixed. We have eliminated complaints due to water in private pipes, which were very frequent in old property. Stoppages during severe weather have also been greatly reduced.

"On the question of pumping syphons, it has certainly saved us £250 per annum."

5. *Plant with Average Daily Treatment of 6·0 Millions (Summer), 9·5 Millions (Winter). (Bournemouth.)*

"The gradual diminution of stoppages due to water and naphthalene. Water stoppages unknown. No syphon pumping required.

"We estimate that the saving in the cost of syphon pumping is in the neighbourhood of £250 to £280 per annum, and the saving in the cost of attending to stoppages is about £300 to £320 per annum."

6. *Plant with Average Daily Treatment of 4 Millions. (Bristol.)*

"Before the plant was started six men were required to deal with the pumping of syphons. Now only three men are required, but we have no doubt a further reduction will be possible later on."

7. *Plant with Average Daily Treatment of 1 Million. (Gas Light and Coke Company.)*

"Water complaints, which were about 450 per annum, eliminated."

8. *Plant with Average Daily Treatment of 0·5 Million. (Great Yarmouth.)*

"Reduction of complaints—formerly sometimes entailed the daily work of three or four men at different seasons.

"No syphon pumping—formerly three days' work each month for one man. Effect on meters—decided falling-off in repairs."

9. *Plant with Average Daily Treatment of 0·87 Million. (Ramsgate.)*

"Reduction of complaints of bad supplies as follows :—

Jan. 1–March 10, 1929	Naphthalene, 376	Water, 177
Jan. 1–March 10, 1930	Naphthalene, 81	Water, 14

We have reverted to the use of steel tubes in place of wrought iron, for, owing to the absence of liquid moisture in mains and services, corrosion is arrested—saving 12½ per cent.

"Former annual cost of tubes, £1200; annual saving is

thus £150. One man's wages, clearing services, &c., annual saving £130. I also expect a considerable saving in repairs of mains and services, owing to longer life of same—for reasons given above.

"Expect reduction in repairs of meters for same reasons."

10. *Plant with Daily Average Treatment of 0·88 Million.* (*Shrewsbury.*)

"With regard to pumping costs, I think I can definitely state that the saving to us is equivalent to 4s. 6d. per million c.ft. made."

In many of the above replies various advantages were referred to, but financial details could not be given. Similarly, in replies from which no quotations have been made, savings under various headings and improved service to the consumer were detailed.

The length of time over which dehydration has been practised is too short to enable figures to be given in respect of savings due to a lessening of meter repairs, more accurate registration, and other headings. As regards the possible savings for which an estimate can be made, average figures could probably be somewhat as follows :—

	Saving per Million C.Ft.
	d.
Reduction in syphon pumping	60
Reduction in attention to stoppages	30
Possible saving in using steel mains in place of wrought iron where new services or replacements are necessary	100
	190

It would thus appear that for plants handling 3 million c.ft. of gas or more per day the savings specified could probably almost cover the capital and operating costs of the dehydration process. When other indeterminate savings have been taken into account, profits might be shown by plants even of small size.

METERS.

It has been mentioned that it is not yet possible to assess the savings in respect of reduced repair costs to meters. In the districts covered by most of the undertakings under review, *dry* meters are either exclusively or to a very preponderating extent in use. The life of such meters is normally of the order of ten years, and many of those in use had already been working for long periods before the introduction of the dehydration system. It must, therefore, be a matter of years before decisive evidence is obtainable, though it may be stated that accelerated service tests are being carried out. It is to be noted that fears that the leathers might be damaged due to the dryness of the gas have proved groundless, since the hydrocarbon vapours present in the gas itself as well as the oil introduced into the gas in the form of atomized oil fog keep the leathers in good condition. In this connection remarks by Mr. Spencer in his presidential address may be quoted :—

> "The effect of gas drying in relation to meters is being carefully noted, as it is anticipated that some considerable time must elapse before any definite statement can be made. One or two encouraging features have, however, been found, the first of which relates to a comparison for the last three years of the quarterly tests made of meters which are brought in on reports of defective working. Of the total number tested and found incorrect, we had in 1927, 38·2 per cent. passing unregistered gas; in 1928, 15·4 per cent.; and in 1929, 11·9 per cent. Again, the last report of one of the meter makers, to whom a portion of our meters are sent for repair, is worthy of mention as in it they state that 'we notice a gradual but very decided improvement in the condition of your meters compared with what it was some time ago.'"

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DISCUSSION.

The PRESIDENT: I wish to congratulate Dr. Smith on the choice of his subject, which is of paramount importance to the industry. When the influence of distribution costs on the cost of gas to the consumer is considered it makes one realize how important it is that any avenue by which these expenses can be reduced should be thoroughly explored.

Dr. Smith has pointed out—and I think it is now generally accepted—that moisture is the chief culprit in corrosion troubles and a host of others referred to in this paper, all of which are a financial burden to distribution. The obvious and the best way to deal with these troubles is to eliminate the cause rather than deal with the effects. For example, it would be a costly matter to be limited in the choice of materials for mains and services, only those which were resistant to corrosion being used. There is no guarantee that such materials are a success in every case, and, in addition, this method affords no relief to all existing mains and services which are liable to corrosion effects.

Dehydration is undoubtedly the soundest policy, and when it is practised another advantage, in addition to those already given in the paper, is that the oxygen content of the gas becomes of minor importance, and this will be of great assistance to purification. It occurs to me that where dehydration has been adopted, the necessary oil film on the surface of the holder water is a case where the necessity has provided, probably inadvertently, valuable means for the preservation of the internal parts of the gasholder, and this must add materially to its life.

Dr. Smith arouses my curiosity when he suggests a by-product of a process of purification in America is being used as an agent for dehydration. Perhaps he will tell us more about it. Our experience with gas dehydration, so far as gas-works in this country are concerned, is confined (with one exception) to the calcium chloride method; this is no doubt due to the reliability and general adaptability to gas-works routine to which the process lends itself.

DEHYDRATION BY REFRIGERATION.

Dr. Smith gives it as his opinion that dehydration by refrigeration would be uneconomical for the treatment of less than 6 million c.ft. per day; but accepting that the cost for a smaller throughput than 6 millions would be greater than when using calcium chloride, the probable results might justify the expenditure.

I refer to the possibility of using gas oil as the chilling fluid, and this, in addition to precipitating the moisture, would take into solution the naphthalene and wash carbon bisulphide out of the gas at the chilling temperature; and it requires no words of mine to point out the inestimable advantages of a gas free from carbon bisulphide. With respect to the problem of wet meters where dry gas was being supplied, I much prefer the use of oil in the meters rather than attempting to limit water evaporation by other means.

In conclusion, I know that Dr. Smith's paper will have been read carefully by most of you, and many of you will be anxious to give personal experiences and ask questions on the points raised, and it is therefore my pleasure to declare the paper open for discussion.

Mr. C. M. D. BELTON (Shrewsbury Gas Light Company): I should like to congratulate Dr. Smith upon his paper and to emphasize one or two practical points. With regard to dust troubles, I was rather alarmed at first that these might be very serious, but my experience has been that these troubles are decreasing very rapidly, and although my plant has not been working for quite two years, the dust troubles have now practically disappeared. They did show up in some services and also

in the boosting mains; I found it necessary to instal a type of dust trap at the inlet of the high-pressure governors on the district, and by using a small and very fine copper gauze I was able to trap the dust without throttling the governor. The difficulty has been almost eliminated now, and it is only necessary to inspect the dust traps at very long intervals. With regard to the syphon pumping costs, I gave an estimate in reply to the questionnaire which was sent out, but I can say now that I think the figure representing savings will be very much larger than the estimated figure when the results of two full financial periods are ascertained. The saving is most material, and, in my own case, for the whole of last year there was only 800 gallons from the whole district, distributing over 300 million c.ft. A point that has been mentioned is that of services complaints. In the year before last the number of such complaints was reduced by 50 per cent., and last year the figure was again reduced by 50 per cent., so that the total to-day is practically negligible. Naphthalene complaints are unknown, and complaints as to no light, bad pressure, and so on are very occasional. The plant works very simply. The only point that has not been raised is that of the determination of the dew point. The hygrometer readings occasionally differ from the calculated figures, and it is necessary to take account of the fact that the viscosity of the fluid—calcium chloride—alters with use. I should also mention that we have found it necessary to instal some kind of filter or settling arrangement for absorbing any solid foreign matter from the froth that comes over with the liquid from the evaporators.

Mr. A. F. H. KNOWLES (Messrs. Kirkham, Hulett, & Chandler, Ltd.) said: First of all I would like to congratulate Dr. Smith on the very excellent paper he has read to us. While I would agree most decidedly that very material results have been achieved by the use of calcium chloride for the purpose of dehydration, I do think that glycerin has certainly a great deal to be said for it, and should receive very serious consideration as a dehydrating agent. I am not for one moment comparing the plants by means of which dehydration is carried out, but merely comparing the results obtainable by means of two different media. You will note that Dr. Smith reports a loss of glycerin on the Colwyn Bay installation of 5 lbs. per million c.ft. of gas. With the second plant of the description which we are installing at Ilkeston, we sincerely believe that this figure will be reduced by more than 50 per cent.—that is, to 2½ lbs. per million c.ft. This will reduce the working costs considerably from the present low figure of 0·2d. per 1000 c.ft.

It can be hardly expected that I should make any comments with regard to calcium chloride, but I should like to point out that if the vapour pressure curves drawn up by Dr. Colman are considered carefully it is clearly shown that glycerin solutions are easily workable at lower vapour pressures than are possible with calcium chloride, since a 40 per cent. solution of the latter is saturated.

From these points we do think, together with the fact that a comparative small quantity of glycerin is used in the plant circuit—viz., approximating 2 tons per million c.ft.—that the use of glycerin for dehydration deserves full consideration from a practical point of view.

Mr. C. COOPER (Messrs. W. C. Holmes & Co., Ltd.): I think Dr. Smith said very kindly that the proper person to have presented this paper was Mr. Cooper. In the last two years I have presented two full size papers, and if you knew the extent to which I have been dependent upon the gas engineers of this country for the information in those papers, you would realize that there was another man better able to compile the next paper—and, judging from this one, I think you have found that man. I have a great admiration not only for the manner in which Dr. Smith has grasped this subject, but also for his presentation of a paper in such a form that other people can grasp it equally well.

DISADVANTAGES OF PARTIAL DEHYDRATION.

In discussing the disadvantages of partial dehydration of gas he refers to the loss of volume due to dehydration. It occurred to me the other day that possibly, in gas going out in a saturated condition, there might be a loss of oxygen content which would not occur in a gas which was not saturated—*i.e.*, the oxidation (the corrosion which we know is going on in the mains) may actually deprive the gas of a definite volume in the form of oxygen. I have not had an opportunity of following this matter up, but perhaps others have been able to find out whether or not there is a difference in the oxygen content of purified gas at the consumer's meter as compared with that of the gas at the outlet of the holder. With regard to gum formation, I should not like to say anything dogmatically, but it is stated rather definitely in the paper that gum formation is attributed to dehydration in some ways. We do know from experience, however, that gums or resins occur on districts where dehydration has not been practised. Perhaps Dr. Smith intended to suggest that, although dehydration was not exactly the villain of the piece—I do not see how it can create gums out of the hydrocarbons—it might act as a sort of *agent provocateur—i.e.*, it will let them come down in positions where they are not wanted, and possibly they would not come down if the gas was saturated. The available evidence in this country concerning the formation of gums is rather dispersed and has not yet been collected to any great extent, and I think that would form quite a good subject for investigation. If Dr. Smith has some physical basis which he can give us in support of his suggestion that dehydration has led to the formation of gums on the districts, I should be glad if he would let us know about it.

With regard to the process described by Mr. Knowles, and which involves the use of glycerin, I was responsible, about two years ago, for the suggestion that the process would probably not remove any quantity exceeding 40 per cent. under working conditions. My more recent information is to the effect that that suggestion was perfectly justified.

Mr. L. H. SENSICLE: I am sure the paper will be referred to for a long time to come by all who wish to investigate the question of gas dehydration. It is undoubtedly a very important question and raises a number of interesting possibilities. A rather curious case came under my notice in which practically the only solution of a certain problem was to dehydrate the gas which was being sent out in an unpurified condition over a long-distance main. It was a supply of coke oven gas which was being taken by a gas undertaking. The gas was being delivered at a fairly high pressure; condensation was taking place in the long main, and the liquid contents had to be pumped out of the syphons. This liquid was found to contain hydrocyanic acid owing to the fact, of course, that the gas was unpurified, and the HCN had not been removed. This was thought to be of no importance. The content of the syphons was pumped out on to the fields through which the main was passing, and the next thing we heard was that certain cows had been found breathing their last. The only solution we could find was to recommend the drying of the gas before it left the coke oven plant; and it might be of interest to those who are in a similar position to be warned of that possibility. I should like to ask Dr. Smith if he can say what concentrations of ammonia were necessary in the gas to cause the precipitation of calcium carbonate in the evaporators to which he refers. I should imagine that the position is rather complicated, and that the percentage of CO_2 in the gas is of some importance, and that you are likely to get a solution of calcium bicarbonate. I should like to refer, also, to the specific statement in the paper that gas dehydration promotes gum formation. In my experience, gum formation has occurred without gas dehydration, and it would appear that it is due more to the use of naphthalene extracting plant, because oil tends to remove from the gas the phenolic compounds which normally act as inhibitors of polymerization or gum formation. As to the effect of tar fog left in the gas by the solutions used for dehydration, is tar fog more detrimental when glycerol is used or when calcium chloride solution is employed? The final point which impresses me is that the specification given in the paper for filming oil would seem to be practically impossible of attainment. Can Dr. Smith say what oil would conform to the seven requirements he gives, and where it could be obtained? The last consideration would be the most difficult.

Prof. J. W. COBB: I should like to say what an interesting paper I think this is. It is remarkable how this process of dehydration has passed into the region of the thoroughly practical as the result of the attention that has been given to it. Nobody will mind my mentioning Mr. Cooper's name particularly in connection with it, because I know the amount of patient work he has put into the problem. Many years ago, before I took up the Livesey Professorship at all, I went into the question of dehydration as it was proposed by the Linde Company, by the method of refrigeration. I remember also that a year or two later a paper was presented to the Iron and Steel Institute in which a certain calcium chloride process was described, which was to be used for blast furnaces, and was in opposition to the refrigeration process which has been proposed by Dr. J. B. Baillie and installed in American furnaces for the same purpose. Now we find that dehydration by calcium chloride in what appears to be a thoroughly efficient and practical form has been put forward for the benefit of the gas industry, and I think it is a very gratifying thing that such a technical achievement has been made possible in recent years.

Mr. JAMES W. WOOD said: It is due both to indefatigable energy and to the esteem in which he is held in the gas industry that Dr. Smith has been able to collect the information and present his excellent and detailed review of gas dehydration to us to-day. I should like to call attention to one or two points. First, as to the regulation of dehydration. With the vagaries of our English climate, reference to the minimum temperature of the preceding week seems to have little justification as the basis of adjustment of dew-point; further, the general trend of temperature-change will be subject to seasonal variation, so that one's allowance will at times be absorbed in the seasonal drift, and at others be unnecessarily large. This voluntary variation in dew-point is also going to increase the difficulty of defining the legal calorific value of gas supplied. What is the position of consumers in this respect, to whom "dry gas" is measured through wet meters?

Dr. Smith details the desirable qualities to be possessed by oil for filming holder-tanks, and for filling "wet" meters.

Has the effect of the gas upon such oils, or of the oils upon the gas, been fully considered?

I understand that upon gas dehydrating plant freedom from corrosion with calcium chloride is achieved by maintaining the solution at a sufficiently high concentration. In the case of any considerable number of isolated wet meters this would present a difficulty, and in addition the meter inspector would have to carry a supply of special fluid for "water-lining" the meters, instead of water, which is so universally obtainable. The same remark applies to other special meter fluids.

The detrimental effect of traces of iron carbonyl upon gas mantles is well known. Similar effects are sometimes observable with the radiants of gas fires. I believe, however, that in many cases it is the residue of ferric oxide from the combustion of atmospheric dust which is responsible for the marked red colour developed, and in some cases the oxidation of iron compounds in the refractory itself. It would be interesting to know how or why leakages are more easily detected and traced when dry gas is supplied. The infiltration of characteristic gas-works compounds into the soil around mains often provides a valuable clue to defects under present systems of distribution.

My remarks seem to have been directed mainly to possible troubles associated with gas dehydration, but I think there is little question that the balance is decidedly in favour of the adoption of dehydration—the view which is, I think, held by Dr. Smith.

Mr. R. J. H. CLARK (Plymouth): I was particularly interested in gum formation and was hoping to have heard some confirmation of the remarks which I understand Mr. Watson made about a year ago in which he said that indene—which was possibly the greatest cause of the gummy constituents—and its kindred bodies were highly soluble in oils, and that by the washing process with gas-oil this would have been entirely eliminated. Apparently we require more information on this subject.

THE COMMERCIAL MANAGER'S POINT OF VIEW.

Mr. W. C. JACKSON (Neath): As one who was more or less compelled by the kindly countenance of our well known Welsh friend, Mr. Octavius Thomas, to give a paper a few weeks ago to the Welsh Institution, I feel that it is only right I should refer to our own experience. In the paper before the Welsh Institution I did not deal at all with the technical side of the subject. I considered it advisable merely to collate definite figures from a practical commercial manager's point of view, and to say that there is a distinct saving to be effected by installing a plant of this description. I am fully convinced that there is a definite saving, and that it is a great deal more than most people realize. There are certain difficulties which one experiences in connection with gas dehydration. Gummy deposits have been mentioned, and they constitute one of the difficulties. We have found these gummy deposits on our station governor valves but not on the district, except, peculiarly enough, on the form of lamp which we use in our principal streets—the Parade lamp, made by Sugg & Co. and also by Messrs. Parkinson, in which you have an upright burner with four nozzles. The gummy deposit builds up on the needles of these upright burners. We have not found the deposit on any other burners at all, where the needle is pointing downwards. I should therefore like to have more information on that matter and to know why the deposits should occur only on these particular burners. I think every case should be fully considered by the engineer in relation to all the circumstances. There are many works which are very modern and fully equipped in which naphthalene extraction is practised, where a fairly high calorific value gas is being made, where there are good sized mains and good falls in the mains, and where they are buried reasonably deep in the soil, and where the conditions are such that one would not go to the expense of putting down a dehydrating plant. On the other hand, where one is bothered by inadequate mains and services, laid at a shallow depth in the soil, and where sometimes there are dips in the services, it will be appreciated that with the variable temperatures experienced here we do get a good deal of water deposition and consequent trouble to consumers. When all is said and done, this question of efficient service to the consumers is the ultimate and vital matter which we as commercial managers must really take into serious consideration, because it is the consumers upon whom we depend for our trade and profit and the success of our undertakings. Therefore, anything we can do to obviate unnecessary trouble and inconvenience to the consumers ought to be done so that we can keep our end up against our competitors. It is about 13 months since we started up our plant, and we have experienced such an increased consumption—and in a district which has been fairly hardly hit by depressed trade in South Wales—that we appreciate and realize that to a great extent it is due to the better service we are giving through being able to give an uninterrupted supply.

Mr. B. R. PARKINSON: The practical application of the dehydration of gas is one of my dreams that has come true. I have been associated very much with the problem of the internal corrosion of mains, and from the evidence it would seem that all corrosion evils occur in the presence of moisture. It might help us in this connection to remember that in our private life we are always talking about moisture. We speak of dry air and moist air in connection with our various diseases. There is also the case of Cleopatra's Needle, which survived for many thousands of years in the dry air of Egypt but is now corroding on the Thames Embankment in London. It has always seemed to me, therefore, that we do not give sufficient attention to the problem of moisture in the gas that we distribute. In the reports prepared by Mr. Tapley and myself for the Life of Gas Meters Committee, we always used to put in a word for the principle of dry gas for high-pressure distribution—which is mentioned in Dr. Smith's paper—but we never got so far as to advocate definitely the dehydration of low-pressure gas. Now, however, it has come to the front, I am exceedingly pleased it has become a practical proposition. Hitherto, with wet gasholders and wet station meters and a certain number of, if not many, consumers' wet meters, the idea of drying the gas at the works has seemed quite impracticable. Now that everything is going dry, there seems to be a possibility of our overcoming corrosion troubles in that way. I should like to make a plea for limiting the oxygen in the gas, because, to put the matter simply and without going into elaborate chemical considerations, it is after all water and oxygen that are the chief considerations in corrosion, and we find that even if the water is taken out of the gas, the oxygen still gives trouble, because it causes the polymerization of the unsaturated hydrocarbons in the gas to take place leaving gummy residues. One other thing is that I have found in my experience that when vaporizing for the prevention of naphthalene, where the gas is saturated with moisture the vaporizing oil is not held and carried forward as one would wish, but that often a great percentage of it comes down at once; and therefore in that respect also it is an advantage for the dew point of the gas to be as low as possible. I have always thought that whereas a great deal of work has been done on the chemical side of gas manufacture, there are three physical matters which might receive, and must receive sooner or later, greater consideration. One is pressure, the second is temperature, and the third is control of moisture content. They all have a relation to one another, and they all directly or indirectly bear on the question of corrosion. The chief point I wish to make is that not only should the question of dehydration be considered, but the oxygen content should be kept as low as possible, and then I think we shall be all right.

Mr. C. F. BOTLEY (Past-President): Recently I have been considering—as we all have—what possibilities there might be of rendering our service to consumers more efficient by the adoption of drying plant, and I have put together a few figures which might be of interest in this connection. I would ask for a very clear discrimination to be made between simple drying and drying combined with naphthalene removal. I think that is vital to a proper understanding of the question, and I say this because, when I first heard the original paper on this chloride extraction process, I was very discomfited, for I felt, in view of the advantages that were claimed, that there was a good deal remiss in my own practice. Among other things I was very concerned as to what had been said with regard to meters. In my undertaking we do not carry out general repairs to meters, and therefore we have not the advantage of being able to get first hand information of the internal condition, in the ordinary way. Therefore, I gave instructions that all meters that were to be condemned or sent back to the makers were to be opened so that we should have some information as to their internal condition. I found, however, that corrosion generally was conspicuous by its absence. In cases where we did find corrosion it appeared generally to have arisen from something having been carelessly blown back into the meters from the clearing of the house pipes. Then I remembered that for a good many years—I think it was for 30 years—I have been in the habit of using oil in the distributed gas; and in referring to the use of oil I would remind you, and especially the last speaker, that I do not vaporize oil. I do not use heat to effect the transfer of the oil to the gas; it is done purely by mechanical means. That reminds me that when I was going into the naphthalene question those many years ago, and when I had not the advantage of association with research chemists such as is possible to-day, and when I made many serious blunders in my theory of chemistry, I did, in fact, come to this conclusion that the presence of water vapour in gas was one of the reasons why we had the deposition of naphthalene; and therefore I tried to eliminate that moisture. I knew then, as a fact, that by compression water was removed, because I was in the habit of compressing gas; and, as a matter of fact, I considered the removal of water by the chloride process, but I had to reject it on the ground of cost, not having the benefit or the opportunity then of installing such a process as is available to-day. The other important point with regard to the drying process seems to be the position of the apparatus. I find—and I expect some others do—that with a long trunk main the gas reaches the holder stations in such a condition that it can be distributed to the district without difficulty arising from water deposition, provided it does not go into the holder. Therefore the assumption is that if the filming is effective in the holders there is no *prima facie* reason for the drying process. I do not say definitely, of

course, that that is so, but it is one of the matters I have now to consider in putting in a drying process—viz., where I shall put the apparatus. Finally, I should like to give one or two figures which I took out with regard to this matter. First of all, as far as it could be calculated—and it is difficult to calculate it because the same main and machinery suit other purposes—last year the cost of oil in our case was £176 on an output of 600 million c.ft. The cost of the free service which we give to all consumers who complained of corrosion and water either in their service pipe or internal pipes, was £144. There was practically no pumping on the trunk main except just outside the works, and the cost of the syphon attendance was £125.

A Summary of the Whole Position.

Dr. A. PARKER: I think this paper constitutes a very fine summary of the whole position with regard to gas dehydration, and the process mainly adopted—viz. the calcium chloride process—is most interesting. I should like to ask whether further information can be given concerning the glycerine process. There is only one works operating that process, and a figure is given for the loss of glycerine on re-distillation in the vacuum still. The point that occurs to me, however, is that glycerine is a good solvent for many substances. It is in between water and an organic compound and has really good solvent properties. Is there any experience to show whether, after rapid distillation, the glycerine takes up various organic volatile substances from the gas and loses, in some measure, its dehydrating properties or changes its viscosity? If it does, then, of course, there will be an additional loss over and above that which results directly from the vacuum distillation, and it may affect the flow of the fluid in the washing plant. Is there any information on that point? Mr. Parkinson has raised the question of the various factors affecting corrosion and has referred to oxygen, which he suggests should be removed. The theory of corrosion is a very complicated matter. People have been working at it for years, and nobody seems to know much about it yet. In fact, at the present time I am mixed up with the problem in connection with water supplies, and there it is more complicated still, because we get bacterial action as well. I think you can take it, however, that for gas it is necessary to have an acid solution of some kind in contact with the metal if there is to be corrosion. You can avoid that acid solution by preventing the deposition of water, and I doubt whether any further removal of constituents, such as hydrocyanic acid, oxygen, and so on, will be found necessary. I think it is remarkable that the simplicity of dehydration of gas to prevent corrosion has not been brought forward earlier.

Dr. Smith's Reply.

Dr. E. W. SMITH: I very much appreciate the quality of the discussion on this paper. It is of such a high order that I think it is better to reply to it after I have been able to consider it in conjunction with further information which I have not at the present time. I will therefore reply at length in writing. Of course it must be understood that I cannot give a proper reply to some of the questions raised, because the process is in a state of development and a half-baked reply would only mislead. The experiences that have been related are confirmatory of the advantage of dehydration, and the questions that have been put relate merely to matters of detail.

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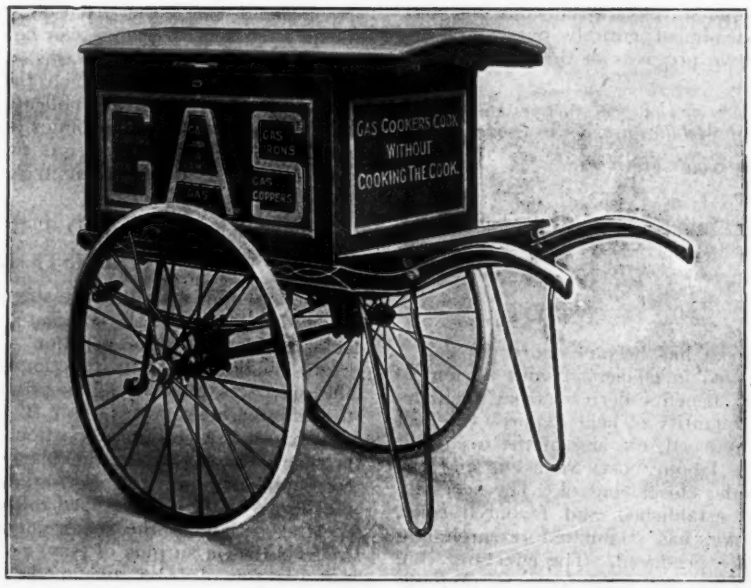

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THE DEVELOPMENT OF THE COKE OVEN.

The carbonization of coal in large chambers, which has resulted to-day in the development of the coke oven type of carbonizing plant, was primarily established for the production of a hard coke for use in blast furnaces in connection with the manufacture of pig iron. For many years this coke has now been produced in the beehive oven, in which the whole of the volatile constituents of the coal are burnt internally to provide the heat necessary. In 1869 the bye-product recovery oven was introduced, but made very little headway for nearly thirty years, as, although the coke produced in these ovens could be used equally successfully, the ironmasters were unwilling to alter their technique to suit the slightly different properties of the new patent coke. Not only was there conservatism among the ironmasters, but for a time coke manufacturers had to be convinced of the value of bye-product recovery by the free installation of recovery plant in return for ten years' yield of tar, ammonia, and benzole.

Quite early in the history of coking it had been appreciated that, provided they were reasonable in ash content, the smalls of the bituminous coals were of equal value to the larger sizes in the production of metallurgical coke. In 1880 the practice of cleaning coal for ash reduction was first introduced, and its application to low value bituminous slacks opened up wide sources of supply for use in bye-product ovens. In fact, the bye-product oven became as much a remunerative outlet for the less readily saleable grades of bituminous coal as an instrument for coke production. In consequence, we find that in England the custom grew up for collieries, in suitable districts, to instal coking plants of sufficient capacity, usually 200-300 tons of coal per day, to deal with the washed smalls produced by each individual pit. As the price of these slacks on the open market was low and the return from the coke produced, aided by that of the residuals recovered, was high, the arrangement was a good economic one, while, having regard to the plant then available, it was as efficient an arrangement as could be made. At the present time over 80 per cent. of the coke oven installations in this country are associated with collieries. Although the prejudice against retort oven coke has died hard, it has now been almost entirely overcome, and Table I. shows the relative progress of the various kinds of ovens in Great Britain.

TABLE I.—*Percentage of Metallurgical Coke Produced in Various Kinds of Ovens.*

—	Beehive.	Non-Recovery.	Bye-Product.
1900	80	13	7
1914	31	7	62
1928	5	1	94

As the bye-product oven has become more popular it has been steadily improved in efficiency, with a view to extending the economic benefits derived from the bye-product recovery. The quantity of heat required to effect carbonization has been reduced, the size of the oven unit has been increased, the labour costs reduced, and the operations conducted under closer control. The necessity for competing with an established and favoured coke, such as was beehive coke, has stimulated research into the properties of the coke produced. The effects of coal size, of the blending of coals and other forms of preparation of the coal charge, of the effects of variation of the oven width, and of the carbonizing time, have been studied closely in several countries, and while to one outside the coking industry there would still appear to be much to be defined, it cannot be denied that headway has been made, and that methods of manufacture of cokes suitable for various purposes, including certain domestic and industrial uses, have been ascertained.

The following table traces the various stages in the development of the coke oven.

TABLE II.

Type of Oven.	Method of Heating.	Quantity of Coke Produced per Ton of Coal Available for Disposal.	Quantity of Gas Produced per Ton of Coal Available for Disposal.	Gas Quality Before Benzole Washing.	Carbonizing Capacity of Each Oven per Day.
		Cwt.	C.Ft.	B.Th.U.	Tons of Coal.
Non-recovery—					
Beehive	Internal burning of gas made	15	*nil*	*nil*	2
Waste heat . . .	do.	14·5	*nil*	*nil*	6
Bye-product recovery—					
(1) Waste heat . .	Part of gas made	14·5	1–2,000	500	6
(2) Regenerative—					
(*a*) Old types .	do.	14·5	4–5,000	500–520	8–9
(*b*) Modern types	do.	14·5	6–7,500	540–560	20–30
(3) Compound . .	do.	14·5	7,500	540–560	20–30
	or producer, blast furnace, or other low-grade gas	12·2 to 14·5	12,500	540–560	20–30

The table shows how greatly modern improvements have increased both the quality and the quantity of the gas yield. In the combination oven the opportunity is given to use either part of the coal gas made, or producer gas, or blast furnace gas at will, for heating purposes, with the result that the yield of high quality gas is increased by some 4000 to 5000 c.ft., or (say) 25 therms per ton of coal. These developments have been inspired mainly by a desire to secure the maximum return from the recovery of the volatile products with a minimum operating cost, with a view to cheapening the cost of coke production. The net result is the evolution of a highly efficient coal processing plant. With the aid of the coke oven, small coal, either from one seam or from a selected blend from several seams, can be converted into the main products, coke and rich gas, that can be profitably marketed for uses for which the original coal is quite unsuited. The practical application of this principle has seriously affected the economics not only of iron and steel manufacture, but of town gas production, and even colliery operations in many countries of the world.

THE COKE OVEN AND THE IRON AND STEEL INDUSTRIES.

The essential association of the coke oven with the iron and steel industries is completed with the provision of coke for blast furnace operation. The blast furnace, however, in addition to its function of extracting iron from the ore, acts also as a gas producer, yielding for each ton of coke at least 125,000 c.ft. of 100 B.Th.U. gas, or 125 therms. A certain proportion of this blast furnace gas is required for heating the blast (say) 35 therms, while the supply of power for blowing, &c., will absorb a further 20 therms if the gas be used for its provision.

After satisfying the requirements of the blast furnace there is then a surplus of (say) 70 therms of blast furnace gas per ton of coke consumed. The production of pig iron requires the consumption of 1·2 tons of coke, which in turn will need the carbonization of 1·7 tons of coal. If the ovens are independent of the furnaces, they will produce, after providing for the heat, &c., requirements of the

ovens, in addition to the coke, 1·7 × 40 = 68 therms of coal gas. The blast furnaces will have surplus 1·2 × 70 = 84 therms of blast furnace gas. If these two are co-operated, and blast furnace gas is used for heating the ovens, the yield of coal gas can be increased to (say) 110 therms, but the surplus blast furnace gas will then be reduced to 42 therms. Thus the production of 1 ton of pig iron can be operated so as to give a yield of 110 therms of coal gas and 42 therms of blast furnace gas, a total of 152 therms.

A steelworks is a consumer of heat and power in its operations for the conversion of iron to steel. The actual quantities of heat required cannot be exactly defined, as they are dependent, first, upon the process adopted, whether open hearth or Bessemer (the former requiring a considerably larger amount); secondly, upon the class of article produced, the more complex articles requiring a greater number of operations and consequently more soaking and re-heating; and, thirdly, upon the amount of scrap steel used. As a figure for argument, however, it can be assumed that the open hearth process, using the "molten pig" process—*i.e.*, 90 per cent. pig iron and 10 per cent. scrap steel—will require for mixing, processing, &c., per ton of steel 80 therms, and for power 30 therms—gaseous firing being assumed. If coal be used in producers to provide this gas, a consumption of about 12-15 cwt. would be required.

The position is, then, that in the operation of both the coke oven and the blast furnace, heat, in the form of gas, is necessarily produced in excess of the works requirements in addition to the main products of coke and iron, while the steelworks is a consumer both of heat, preferably in gaseous form, and of iron. It will also be noted that it should be possible to satisfy these heat requirements from the total surplus heat produced in consequence of the iron and coke manufacturing processes.

This situation is even more favourable where the Bessemer process is adopted, as not only are the heat requirements less, but 1·2 tons of pig iron are required to produce 1 ton of steel, so that there is more surplus heating gas available.

Alternatively, in those cases where the open hearth furnace is used in conjunction with a "mixed process"—that is, one in which the proportion of scrap used is increased up to 50 per cent.—the steelworks heat requirements are somewhat increased, while at the same time the quantity of blast furnace and coke oven gases available is obviously much reduced. In these circumstances there will be insufficient heat available to supply the steelworks, so that the whole of the gases could be absorbed, and, in addition, any further blast furnace gas produced in the course of the manufacture of iron not intended for subsequent conversion to steel.

In British works of recent years the use of scrap up to 50 per cent. and the open hearth furnace is commonly met with.

The four essential works in the manufacture of steel—*i.e.*, the colliery, the coke oven, the blast furnace, and the steelworks, can be operated as separate units or they can be combined in a number of ways to secure:

(*a*) Minimum transport costs of coal, coke, iron ore, and iron.

(*b*) Minimum consumption of coal.

(*c*) Ease of shipment of finished steel.

In America the steel industry has for many years been in the hands of undertakings controlling ore, coke, iron, steel, and transport, under one management. The improved gaseous yield from the modern coke ovens has enabled such undertakings to make the maximum use of the effects of the thermal interlocking of the ovens, furnaces, and steelworks, and has resulted in the formation of combined works of considerable magnitude. Probably the largest of such undertakings is the Clairton Works of the Carnegie Steel Company, where the ovens carbonize 11 million tons of coal annually. This thermal interlocking has had the active approval and support of eminent technologists for many years, but it should be remembered that for complete success a balance of heat production and requirements is necessary throughout the combined works, while there is necessarily a loss of oven and blast furnace gases over the week-ends and other periods when the steelworks are idle or not running at normal load. In consequence it is generally agreed that success is not possible with combined works manufacturing less than 2500 tons of steel per day, and is not completely achieved until a capacity of 5000 tons per day is reached. The extent, however, to which the United States has approached the ideal is shown by the fact that 97 per cent. of the coke produced and 65 per cent. of the surplus gas yield of ovens connected with the iron and steel industry is used internally. Further, it may be of interest to note that of the total oven coke produced in that country 75 per cent. is produced in plants owned by the iron and steel industry.

In Germany a similar state of affairs has prevailed, and has been much encouraged by the extensive reconstruction of plant that has taken place since the war. The Hamborn Works of the United Steel Company (Vereinigte Stahlwerke), for example, produces some 4000 tons of finished steel daily with a coal consumption in the ovens of 4500 tons—the whole of the gas and coke produced being used in the processes, but power requirements being purchased In the Ruhr area five combined works, of which this is the largest, produce the equivalent of 60 per cent. of the total British steel output. That it is not necessary for all the combined works to be within one boundary is shown by the case of the Hansa Works of the same Company. Here coal is brought to the ovens by ropeway and rail from three pits distant four, two, and two miles respectively from the ovens. The ovens have a daily capacity of 2400 tons of coal, and are fired with blast furnace gas brought through a 6 ft. 6 in. diameter main from the furnaces, producing 2000 tons of iron daily, while the oven gas is sent to the steelworks, which employ the Siemens Martin process, four miles distant. The whole installation of ovens, which is now but 2½ years old, was especially designed to secure the shortest conversion of iron into steel.

The United Steel Works Company is at present using 100,000 million c.ft. annually of low-grade gas—producer and blast furnace—to heat its ovens and steelworks, and 28,000 million c.ft. of coal gas made available is used in its works.

In England, as has been previously mentioned, the coke ovens are mainly associated with the collieries. The ironworks have been erected near deposits of ore and the steelworks, and though occasionally associated with the blast furnaces, are often found isolated from collieries, ovens, or furnaces. There are only a very few combined ovens, ironworks, and steelworks. Furthermore, the average output of the steelworks installations is only some 500 tons per day. This independence of operation results in a fuel demand of 2 to 3 tons of coal per ton of steel, in place of the ideal attained elsewhere of under 1½ tons.

To secure the conditions obtaining abroad, however, would need a complete reconstruction of plants and a revision of site in most cases. It may be that some such reconstructions will take place in the future when the British steel industry reaches more prosperous times. It is, indeed, seriously contended by some authorities that the whole future of our British iron and steel industry, for both home and export, lies in the eventual abandoning of the present diverse units, and in the erection, near the coast, of the large combined plants which are a feature of American and Continental practice. It will be remembered, for example, that the 1918 Coal Conservation Committee stated their satisfaction that a strong case existed on theoretical and practical grounds for the erection of combined plants, preferably of 500,000 tons annual steel output, and that the grouping of these units in conveniently situated districts was one of the fundamental conditions of success of the iron and steel industry. At present the most pressing problems would seem to be the location of the new ovens which must be erected soon to replace existing coking plants that are in many cases over 25 years old, the ownership of such ovens, and the making available to steelworks of the additional gas that will then be produced if they should not be erected in conjunction with them.

This last question raises the issue of thermal *versus* financial economy. In colliery districts raw coal may be considered as being worth to the consumer ½d. per therm, producer gas 1¼d. to 1½d. per therm, coke oven gas a little more than producer gas, (say) 1¾d., and blast furnace gas rather less, (say) 1d. for fuel purposes.

Many industries need gas with better characteristics than

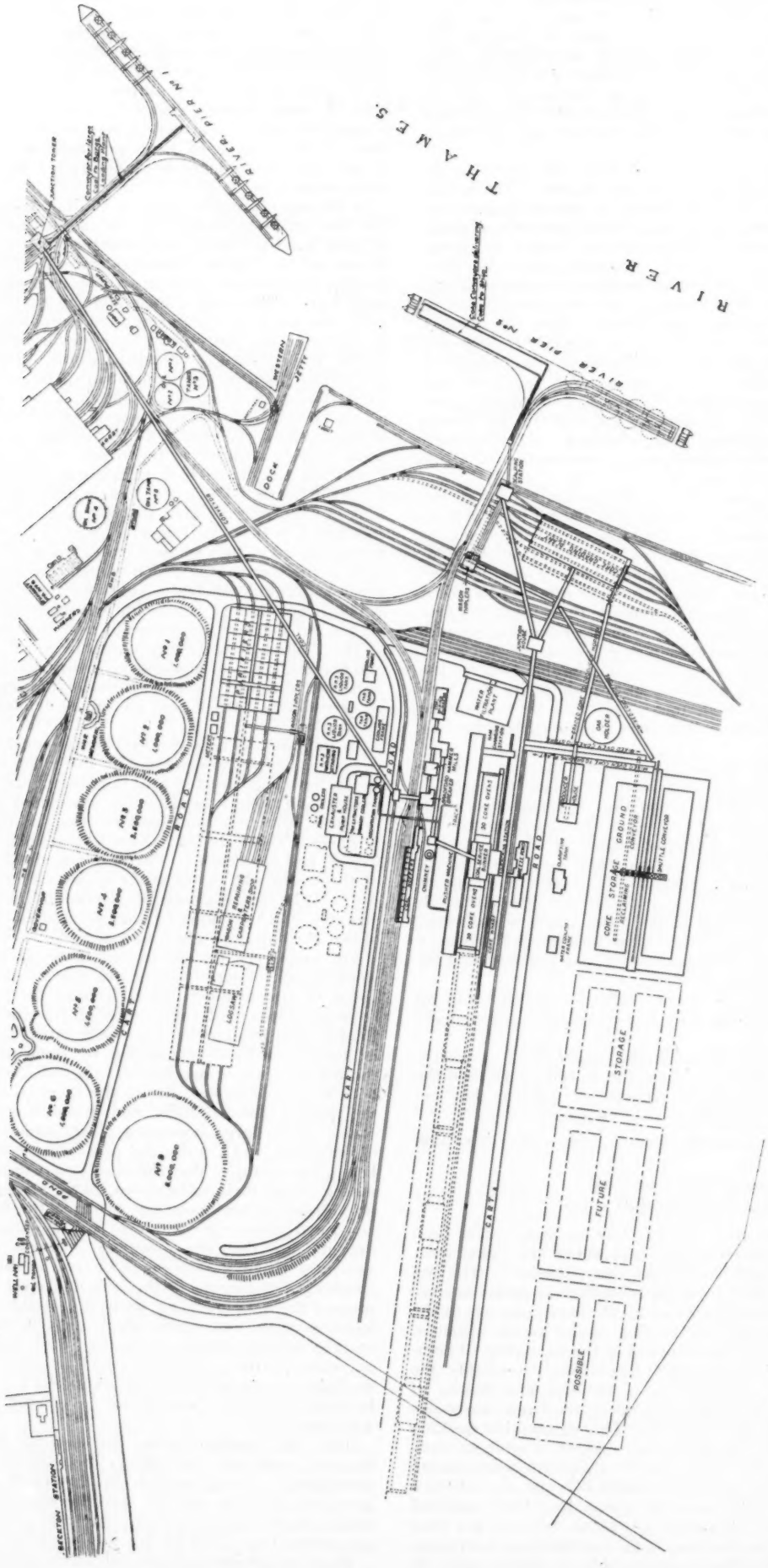

FIG. 1.—PLAN OF COKE OVEN SITE, BECKTON.

producer gas or blast furnace gas, and the advantages are such that competition with other fuels, liquid and solid, can be met with a price of 4d. to 6d. per therm for such gaseous fuel. This is seen to be the case in connection with the growing demand for town gas for many industrial purposes, which is so noticeable a feature of the gas services of (say) Birmingham, Coventry, London, and Sheffield. If coal gas can be successfully sold for industrial uses at a higher price than the value of coke oven gas to steelworks, the question arises whether, provided the cost of distributing and marketing oven gas is less than the difference between the value of oven gas to the steelworks and its value to the industrial consumer, real economy in iron and steel manufacture cannot also be secured in an equally successful manner by the outside sale of such oven gas. The ability to sell the gas depends primarily on a market being available. In the case of the United States and the Ruhr, for example, the enormous output of steel and iron results in the production of such quantities of gas, in proportion to the industrial demand for coal gas within a reasonable distance of the ovens, that any question of such sales as an influence on economic policy is seen to be useless. In this country, however, with small and scattered works in industrial areas, it is not difficult to find conditions—(say) around Sheffield or Newcastle—where a demand might exist for cheap coal gas which could be met by the sale of oven gas.

By the Acts of Parliament regulating the gas industry of this country, the right of sale of any such gas is placed in the hands of the local gas undertakings, and it may be safely presumed that these undertakings are fully alive to the possibility of improving their sales by making available cheap gas to the limit of their ability, which is often fettered by difficulties in the matter of charging at the present time.

If the coke oven is to be separated from the iron and steel works, there would appear to be no physical reason why it should not be attached to the gas-works, and there be operated as a unit of gas manufacturing plant catering for the metallurgical coke trade, and furnishing gas to industry, and even to steelworks, through the existing mains network.

THE COKE OVEN AND THE GAS INDUSTRY.

The use of coke ovens by gas-works has already been the subject of four papers presented to this Institution, the most recent communication having been made in 1927 by Mr. G. M. Gill. On that occasion the various designs of ovens, both large and small, which had been adopted by gas undertakings in America and elsewhere were considered in a detailed manner as to both construction and operation.

Abroad, progress in the installation of coke ovens on gas-works has been well maintained. In the United States at least 24 gas undertakings to-day operate coke oven installations, which have an annual carbonizing capacity of over 6 million tons of coal. One-half of these ovens with an annual capacity of 4 million tons of coal have been erected since 1926. Last year American gas undertakings distributed 50,000 million c.ft. of gas from their own coke ovens, equal to 11 per cent. of the total gas manufactured and being an increase of 28 per cent. over the corresponding figure for 1928. Similar extensions are taking place in Canada, the most recent installation being one at Montreal of 1250 tons per day capacity.

In Europe similar progress can be recorded. Eighteen gas undertakings are operating 830 ovens which can carbonize 2,500,000 tons of coal annually, and one-third of these, dealing with 1,000,000 tons annually, have been put to work since 1926.

There would thus appear to be a *primâ facie* case for the general use of coke ovens by gas-works. Two bases for consideration exist—(1) expediency in respect of coke quality, and (2) economy in carbonization.

It is within the knowledge of the author that the change to coke ovens from the conventional inclined and continuous vertical retorts, the latter but five years old, was dictated at Stockholm in 1918 because of the demands of the local coke market.

This superiority of oven coke for certain local domestic markets was referred to in several papers at the recent World Power Conference, thus:

Canada, B. F. Haanel. Paper G.1.

> "Coke had for a long time been used to some extent as a domestic fuel in those centres of population where gas-works were operated, and gas house coke, but more especially metallurgical coke, was recognized to possess many of the physical characteristics of American anthracite.
>
> "Naturally, therefore, the bye-product recovery oven was favoured as a type of plant which could be employed to the best advantage for the manufacture of a domestic fuel from coking bituminous fuels;"

and later,

> "The bye-product recovery oven has in several instances replaced the conventional gas retort, and with complete satisfaction. This change is due in a large measure to the demand for a better domestic coke."

In the paper by the U.S.A. Bureau of Mines, H.6:

> "The great increase in the quantity of bye-product coke sold for domestic use has been an outstanding feature of the fuel market in the United States:—
>
> 1918 . . . . . 1,408,000 tons
> 1927 . . . . . 4,703,000 tons
> 1928 . . . . . 6,200,000 tons."

On the Continent of Europe the extensive use of closed stoves for heating has always favoured the selection of a dense coke. The intermittent vertical retort and the inclined chamber have for this reason found favour in the past in Germany and France. It is not surprising to find that oven coke has secured a considerable entry into the domestic market there in recent years.

It is suggested, therefore, that the adoption of coke oven plant by gas undertakings abroad has been influenced to a considerable extent by the nature of the coke appreciated by the domestic user.

In England the use of the open grate, and the rapid rise to popularity of the small coke boiler, has yielded a general preference for a more easily combustible coke. In consequence, coke of the character produced by the horizontal retort, and, to a greater extent still, by the continuous vertical retort, has in recent years been in demand.

At the same time, it must be noted, there has been a considerable increase in the sale of oven coke, in the last decade, for domestic purposes, the reasons attributed being:

(*a*) Price.
(*b*) Low ash and moisture content.
(*c*) Careful sizing.
(*d*) Ability to withstand transport and storage without breeze production.
(*e*) Suitability of coke of this character to large central heating stoves and situations commanding a good draught.

In a paper presented to this Institution in 1922, Mr. W. B. Leech, referring to extensions of plant at Beckton, said: ". . . The coke oven scheme proved the most attractive from the money point of view, being about 1d. per therm cheaper than verticals, which came next in order of cost; but this advantage, which was chiefly due to the better quality of the coke produced, was discounted by the uncertainty of the market for this class of coke in the London area."

This hesitancy was justified, as in 1927* Mr. T. Hardie said, referring to coke ovens: "It has not yet been possible, however, to show a balance sufficiently favourable to justify the installation of this type of retorting plant in the Gas Light and Coke Company's area when all the conditions in regard to both erection and working are taken into account for specific instances." In 1928 and 1929 further inspections of coke oven plants in America, on the Continent, and in this country were made by members of the Gas Light and Coke Company's staff. In all, some 26 plants treating in the aggregate over 40,000 tons of coal per day were inspected. From the data secured a very close estimate of the value of coke oven plant was

* Presidential Address, Southern Association of Gas Managers.

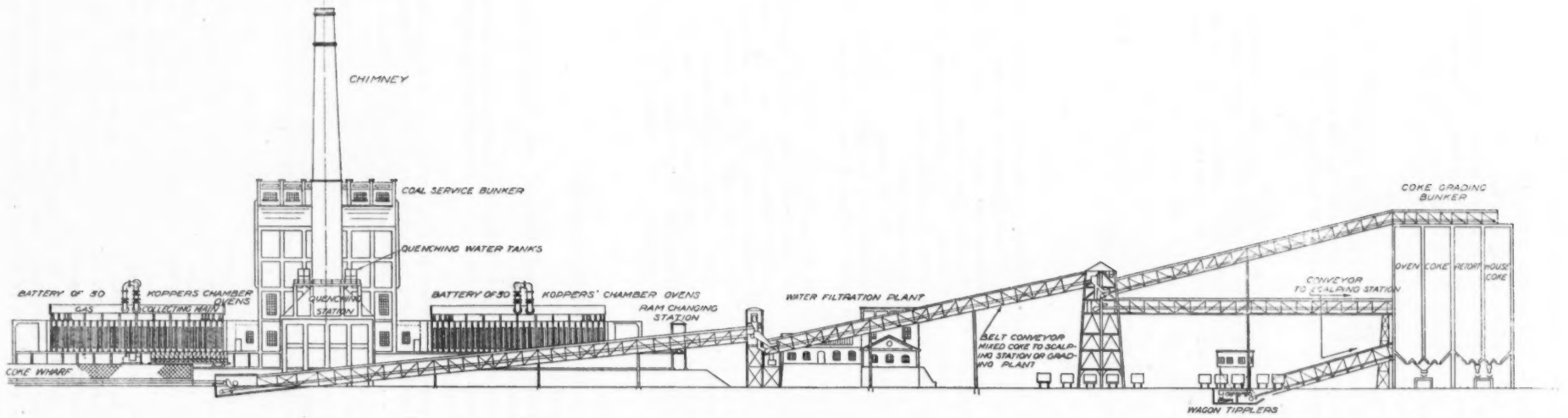

FIG. 2.—FRONT ELEVATION OF OVENS AND SECTION OF COKE GRADING PLANT.—GAS LIGHT AND COKE COMPANY'S BECKTON STATION.

made, and, ultimately, although the resulting comparisons were not too favourable, it was decided to lay down at Beckton a section of coke oven plant to have a capacity in the first instance of 1200 tons per day, but arranged to form, if ultimately extended, the nucleus of two 2400 tons per day units. This plant, which is now being erected, will be described in the Appendix.

The advantages claimed for the coke oven as a carbonizing plant are:

(1) Low labour cost.
(2) Low fuel cost.
(3) Long life of ovens.
(4) Low maintenance costs.
(5) Coke quality under control.

The disadvantages are:

(1) Large ground space required.
(2) Some production of steam and smoke.
(3) Gas yield less than good horizontal retort practice.
(4) Lack of flexibility in output, particularly if coal gas is not to be used at times as fuel.
(5) Economy in labour, capital, &c., is only secured in large units.

The economy of a coke oven plant is a function of the size of the oven unit and of the number of operations that can be carried out daily by one set of machines and their crews. The modern oven holds a charge of 15 to 20 tons, and 160-200 ovens can be charged daily with one set of machinery. This defines the most economical unit as being between 160 × 15 = 2400 tons and 200 × 20 = 4000 tons per day.

It will be seen that the Beckton plant has been arranged to suit the former capacity. For comparison with conventional gas-works practice, however, it is proposed to consider a 1200-ton per day unit as one being of sufficiently low capacity to be of interest to several gas-works, and yet large enough to possess most of the advantages of the modern design.

Comparison will be made, principally, with some of the recently constructed continuous vertical retort installations in use by the Gas Light and Coke Company, the largest of which is of 646 tons of coal per day in capacity. The coke oven installation, therefore, has a considerable initial advantage in size. The comparison is made in a series of tables, as follows:

Capital Cost of Ovens.

This is shown in Table III., and may be compared with a similar cost for a large continuous vertical retort bench complete with producers and waste-heat boilers of £249 per ton carbonized per day.

TABLE III.—*Capital Cost of Modern Combination Coke Oven Carbonizing Plant of a Capacity of 1200 Tons of Air Dry Coal per Diem.*

—	Cost.	Cost per Ton per Day.
	£	£
Coal crushing and elevating plant	32,000	26·7
Central coal storage tower – 3600 tons	34,000	28·3
Oven battery of 60 ovens in one bench, complete with all fittings, mains, self-sealing doors, charging and discharging machinery in duplicate, &c.	186,000	155·0
Coke quenching plant, coke cars, loco, coke wharf, loading conveyor	21,000	17·5
Total oven plant	273,000	227·5
Gas producer plant, house, mains, regulating holder, machinery, coolers, &c.	62,000	51·7
Total oven plant and producers	335,000	279·2

In all cases the figures include the cost of foundations.

The item of £51·7 per ton per day for producer plant for the coke ovens should be noted, as when oven gas or blast furnace gas is available, as in ovens for colliery or iron-works use, this expense is not incurred.

Labour.

Comparison of the number of operatives required for

a 1200 tons per day coke oven and a 646 tons per day vertical retort installation is given in Table IV. :

TABLE IV.

—	Coke Ovens. 1200 Tons per Day.	Continuous Vertical Retorts. 646 Tons per Day.
Coal—		
From crushers to storage bunker . . .	2	1
Carbonizing—		
From coal in bunker to coke discharge .	30	44
Producers—		
Feeding, cleaning, and attending . . .	22	Included in carbonizing
Coke—		
From bench to delivery at handling plant, including quenching	9	3
Incidentals—		
Foremen, lobbies, flushing mains, odd labour	18	8
	81	56
Tons per man—		
With producers	14·8	11·5
Without ,, ...	20·7	..

It will be noticed that in the case of the coke ovens one man deals with 14·8 tons of coal, while the corresponding vertical retort figure is 11·5 tons of coal.

In the lower part of Table V. (appearing below), which is an extension of one previously published by Mr. T. Hardie, these labour expenses are shown converted to pence per ton of coal carbonized and compared with various examples of horizontal, inclined, and vertical retorts. A month's working has been taken, so that Sunday working rates are included.

Ground Space.

The upper portion of Table V. compares the sizes of ovens or retorts, thermal outputs, weights of charges, &c., of these systems. In particular, it illustrates the high yield of therms per square foot of site—viz., 3·55—secured with the modern vertical retort, and the progress made in this respect. The figure compares with 1·48 therms for horizontal retorts and with 0·93 therm only in the case of coke ovens.

Fuel.

Coke oven design, and heating practice, is based upon the use of a clean heating gas and efficient regeneration so that the exit combustion gases are at a temperature not exceeding 350° C. In this way the consumption of heating gas has been brought down to a figure which should not average more than 1000 B.Th.U. per pound of coal carbonized, and claims are made for figures as low as 750 B.Th.U. If this gas is producer gas made in mechanical producers from the small coke and breeze, an efficiency of 75 per cent. is the best that can be obtained, and so 1333 B.Th.U.

TABLE V.

Type of Plant	1. Inclined.	2. Horizontal.	3. Continuous Verticals.	4. Continuous Verticals.	5.	6. Coke Ovens (Including Producers).
			1926.	1927.	1930.	
Size of retort house	310 ft. by 63 ft.	360 ft. by 65 ft.	192 ft. by 60 ft.	210 ft. by 63 ft.	209 ft. by 68 ft.	540 ft. by 170 ft.
Number of retorts	240	270	128	68	72	60
Size of retorts	24 in. by 18 in. by 20 ft.	24 in. by 18 in. by 23 ft.	33 in. by 10 in. to 39 in. dia. by 25 ft.	78 in. by 10 in. to 82 in. by 18 in. by 25 ft. 9 in.	100 in. by 10 in. to 104 in. by 18 in. by 26 ft. 8 in.	14 ft. high by 18 in. wide by 39 ft. 3 in.
Power	Steam	Electric	Electric	Electric	Electric	Electric
Coal	Midland	Durham	Durham	Yorkshire	Durham	Durham
Coal per month (average)	9200	14,400	12,400	16,485	20,026	37,200
Coal per full day	306	480	400	532	646	1200
Charge per retort	9·2 cwt.	19·5 cwt.	3·4 tons per day	8·3 tons per day	9·64 tons per day	15·83 tons
Duration	8·5 hours	12·0 hours	..	..	..	19 hours
Coal per retort (working) per day	1·3 tons	1·95 tons	3·4 tons	8·3 tons	9·64 tons	20·0 tons
Therms per retort (working) per day	94·9	140·4	265·2	655·7	751·9	1420
Therms per ton	73	72	78	79	78	71
Therms per day	22,338	34,560	31,200	42,028	50,388	85,200
C.ft. per day	4,150,000	6,250,000	6,120,000	8,170,000	9,883,800	15,500,000
Average of retorts gas making	235	246	117	64	67	60
Area of site sq.ft. gas making	19,500	23,400	11,520	13,230	14,212	91,800
C.ft. of gas made per 24 hours per sq.ft. of site	212·8	267·1	531·2	617	695	169
Therms made per 24 hours per sq.ft. of site	1·15	1·48	2·71	3·18	3·55	0·93

CARBONIZING WAGES—PENCE PER TON OF COAL CARBONIZED.

[Including normal Sunday working.]

Coal (from delivery to bunkers to crushers)	1·75	0·54	0·42	0·35	0·23	0·26
Carbonizing coal (from bunkers to coke to conveyors and furnaces)	23·79	11·12	11·18	8·61	8·00	6·33*
Coke (coke from retort house to storage in bunkers)	16·00	0·93	1·04	0·79	0·66	1·14
Incidentals (foremen, lobbies, &c.)	3·54	3·31	3·29	2·36	1·91	2·20
Total wages	45·08	15·90	15·93	12·11	10·80	9·93

* Ovens, 3·81. Producers, 2·52.

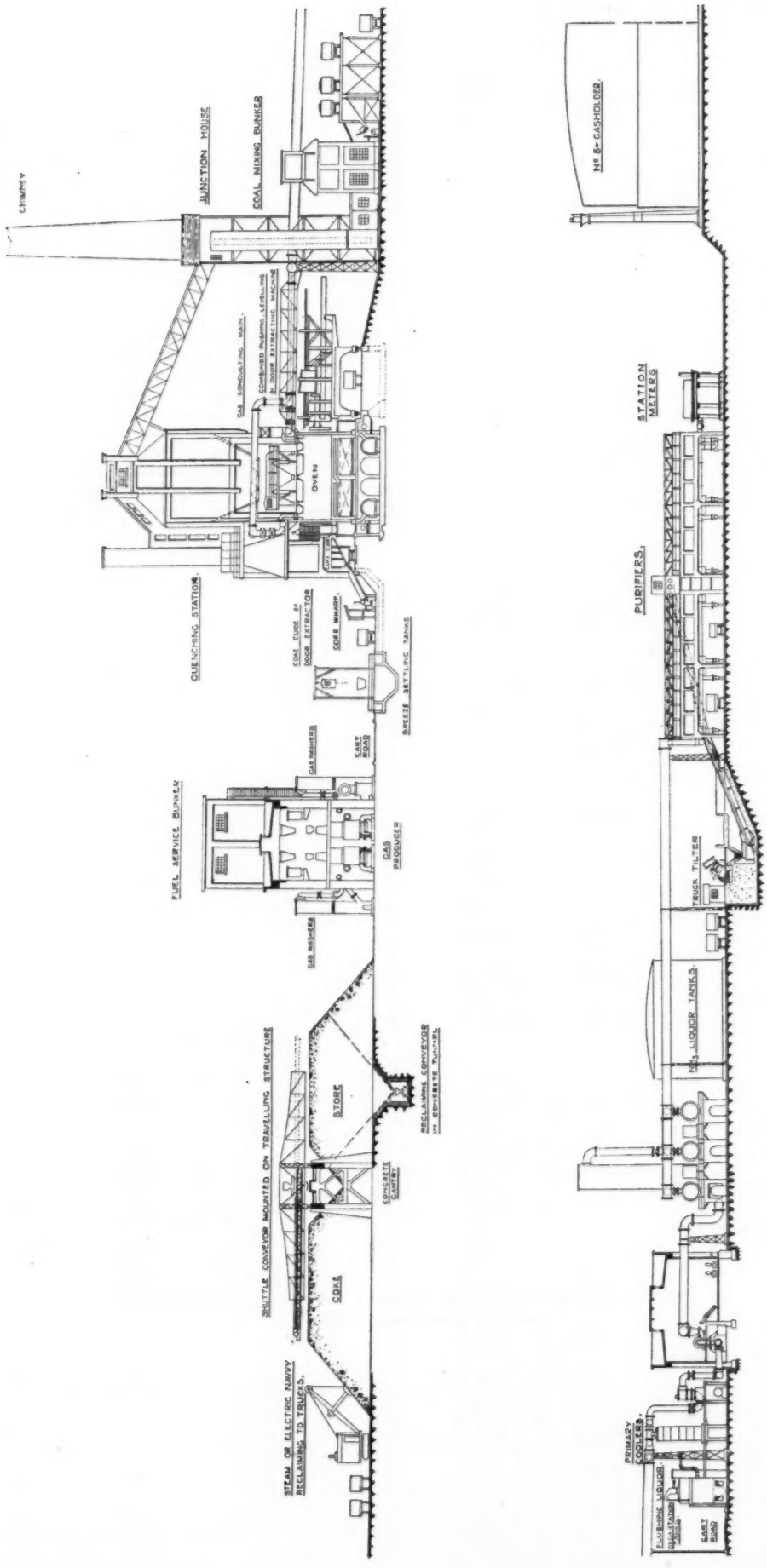

FIG. 3.—CROSS SECTION THROUGH COKE OVEN PLANT.—GAS LIGHT AND COKE COMPANY'S BECKTON STATION.

per pound of coal in the form of coke are needed to produce the necessary gas. This figure is considerably below the usual fuel figure of 1875 B.Th.U. per pound of coal (3 cwt. of large coke per ton of coal) met with in gas-works. If, however, credit be taken for the heat that can be, and is usually to-day, recovered in retort houses in the form of steam by waste-heat boilers, then the vertical retort shows a superior figure of 949 B.Th.U. per pound of coal.

Table VI., which compares the heat requirements of horizontal and continuous vertical retorts with coke ovens, has been calculated from data given in a paper by Mr. T. Hardie before the Institute of Fuel.

TABLE VI.—*Approximate Quantities of Heat Used in Carbonization of One Pound of Coal.*

—	Horizontal Retorts.	Continuous Vertical Retorts.	Coke Ovens.
	B.Th.U.	B.Th.U.	B.Th.U.
Heat required in coke, &c., supplied to producers	1875	1637	1330
Heat required in fuel gas entering the bench	1685	1440	1000
Heat used and lost in bench	1038	505	687
Heat recovered as steam in waste heat boilers from exit flue gases	406	688	..
Heat leaving in waste gases through chimney	214	202	313
Heat supplied to producers, less heat recovered as steam (if any) = gross heat used in carbonizing	1469	949	1330
Heat entering setting less heat recovered as steam (if any) = net heat used in carbonizing	1279	752	1000

Maintenance.

Experience derived from the working of several installations of continuous vertical retorts indicates that the average cost of maintenance of the sequence of plant between the delivery of coal to the crushers and the discharge of coke to the screening and storage plant is 5½d. per ton of coal. To this must be added the cost of periodic resetting of the retorts, which averages 8d. per ton, giving a total cost of 1s. 1½d. per ton. For horizontal retorts the corresponding figures are 8½d. and 5½d., a total of 1s. 2d. In the case of coke oven this figure has been difficult to ascertain, owing to the different methods of accountancy used by owners of ovens. On the same bases as the gas-works figures, given the normal maintenance of the ovens, coal plant, coke wharf and conveyors, machinery, &c., but excluding producers, they would appear to be 4d. per ton of coal handled, and the resetting of the ovens every ten years 3d. per ton of coal, while the outside producers which are necessary to heat the ovens when used for gas-works operation would add a further 2·5d. per ton, a total of 9·5d. per ton of coal.

COMPARISON OF GAS-MAKING COSTS.

The preceding comparisons have been brought together in Table VII. (given below), and the various costs tabulated per ton of coal, the cost of manufacturing 1 therm in the form of crude gas being deduced therefrom. There are three main comparisons—viz., between the horizontal, vertical, and coke oven plants as detailed in columns 2, 5, and 6 of Table V.; but a fourth comparison has been added giving an estimate of the cost of gas-making in a coke oven plant fired with part of the coal gas made and supplied with coal and selling coke at "colliery" prices. Reference to the result of this determination (Coke Oven B) will be made later.

The net result of the comparison is to show costs of gas making as follows:

Coke ovens, 1200 tons per day . . . . 1·804d. per therm.
Continuous verticals, 646 tons per day . 1·815d. ,, ,,
Horizontals, 480 tons per day . . . . 2·099d. ,, ,,

When the daily capacities of the installations are taken into account, the continuous vertical retort is shown to be the cheapest gas-making proposition, and, as the coke produced by it finds a ready market, the absence of the

TABLE VII.—*Comparative Carbonizing Costs.* (*Basis per Ton of Coal.*)

—	Continuous Verticals.	Coke Ovens. A.	Coke Ovens. B.*	Horizontals.
Average work per year	(300 days)	(330 days)	(330 days)	(290 days)
Therms made per ton	78	71	48	72
Coke made for sale per ton, cwt.	9·79	12·4	13·4	9·8
Breeze ,, ,, ,, ,,	1·42	..	0.6	1·4
Breeze purchased for fuel per ton, cwt.	..	1·0	..	..
Tar made per ton, galls.	11·0	10·0	10·0	10·0
Liquor made per ton, galls. (10 oz.)	29·0	29·0	29·0	29·0
Capital cost per ton per day	£249	£279	£227	£260
Capacity of installation per 24 hours	646 tons	1200 tons	1200 tons	480 tons
	Cost per Ton of Coal.	Cost per Ton of Coal.	Cost per Ton of Coal.	Cost per Ton of Coal.
	s. d. s. d.	s. d. s. d.	s. d. s. d.	s. d. s. d.
Cost of coal	21 6·00	21 6·00	10 0·00	21 6·00
Less—				
Coke (19s. 6d. per ton)	9 6·54	12 1·08	10 0·60	9 6·66
Less value of breeze purchased		0 4·20		
		11 8·88		
Breeze (7s. per ton)	0 5·96		0 1·08	0 5·88
Tar (2½d. per gall.)	2 3·50	2 1·00	2 1·00	2 1·00
Liquor (1s. per butt)	0 3·22	0 3·22	0 3·22	0 3·22
	12 7·22	14 1·10	12 5·90	12 4·76
	8 10·78	7 4·90	*Cr.* 2 5·90	9 1·24
Less surplus waste-heat steam generated—				
At 5s. per unit of 10,000 lbs.	0 6·00	..	..	0 6·00
Net coal	8 4·78	7 4·90	2 5·90 *Cr.*	8 7·24
Wages	0 10·80	0 9·93	0 6·90	1 3·90
Electricity for power	0 0·52	0 3·50	0 1·26	0 0·70
Wear and tear	1 1·50	0 9·50	0 7·00	1 2·00
	10 5·60	9 3·83	1 2·74 *Cr.*	11 1·84
Capital charge—				
At 8·024 per cent. per annum	1 3·98	1 4·28	1 1·25	1 5·27
Cost per ton	11 9·58	10 8·11	0 1·49 *Cr.*	12 7·11
Cost per therm (unpurified gas)	0 1·815	0 1·804	0 0·031 *Cr.*	0 2·099

* In this case the following prices are used: Coal, 10s. per ton; coke, 15s. per ton; Breeze, 3s. per ton.

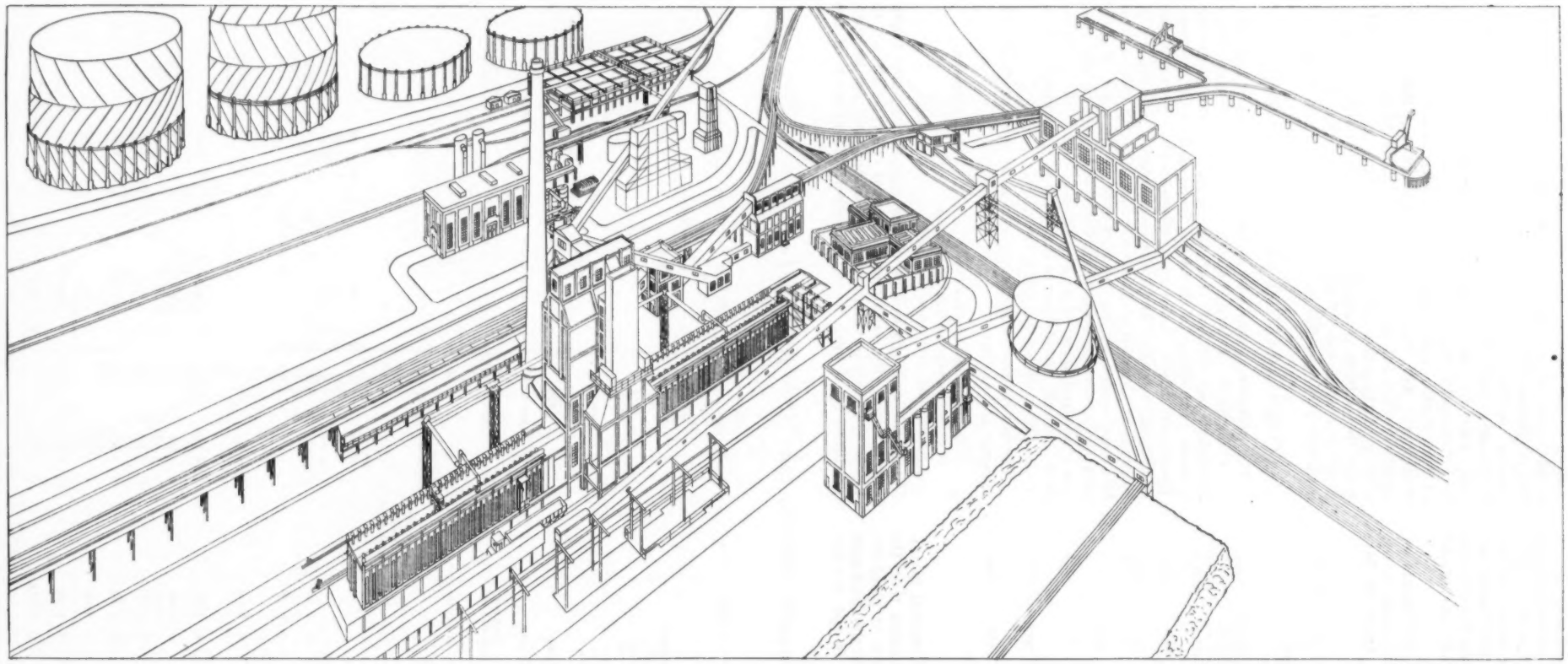

FIG. 4.—PERSPECTIVE VIEW OF 1200 TONS PER DAY COKE OVEN PLANT, BECKTON.

coke oven from British gas-works equipment is not difficult to explain.

The necessity of installing a large plant to secure economy in labour, and from the capital cost of machines, quenching plant, coke wharf, coal plant, bunker, &c., acts as a further deterrent. All charges connected with these will increase as the size of the unit is diminished. It is essential, therefore, if coal gas is not to be used for firing, that the ovens be worked continuously as a "base load" plant. The total costs of manufacturing producer gas, cold and free from dust, including labour, fuel, capital, and maintenance, such as is required for oven firing, will cost no more than 1·5d. per therm—there is thus no inducement to burn coal gas at 1·8d. per therm as fuel at any time.

A coke oven plant of 1200 tons of coal per day capacity, used as a "base load" plant, will carbonize 432,000 tons per annum. Assuming the daily summer load of a gas-works to be equal to one-half of the daily winter load, and the normal annual make to be 220 times the maximum winter day demand, the use of a plant of 1200 tons capacity is limited to undertakings carbonizing not less than 528,000 tons annually. There are but four gas undertakings exceeding this size in Great Britain—viz., Glasgow, Birmingham, South Metropolitan, and the Gas Light. Together these four treat 30 per cent. of the coal carbonized by the gas industry. Glasgow, however, is purchasing oven gas as well as having recently installed vertical retorts, Birmingham has recently changed over from coke ovens to vertical retorts, while the Gas Light position may be explained by their having at their Beckton Works a definite outlet for the type of coke produced, a suitable site, together with an output giving the ability to install ovens of sufficient size to compete in cost with vertical retorts, rather than by any definite conviction, at present, as to the future of coke ovens as gas-works plant.

If we assume that a decrease in size to 600 tons per day capacity might not so sufficiently increase the cost of gas-making as to make vertical retorts a distinctly better proposition, then ovens may be considered as suitable for undertakings carbonizing over 264,000 tons of coal annually. This assumption would, however, embrace only

four additional undertakings—viz., the Commercial Company, Liverpool, Manchester, and Newcastle. The last of these is already purchasing oven gas extensively, conditions of site would seem to prohibit the use of ovens by the first, while Manchester has recently put to work a new works equipped with horizontal and vertical retorts. It is probable that but for their extensive purchases of coke oven gas Sheffield would come in this group also.

To sum up, then, the oven as a gas-works carbonizing plant in this country :

(1) Would seem to be of interest to only the eight largest undertakings, who together treat some 37 per cent. of the total coal carbonized by the industry, and to have been rejected already by several of them.

(2) Cannot compete with continuous vertical retorts unless of over 1000 tons per day capacity.

(3) Requires a ground space greater than any existing gas-works carbonizing plant.

(4) Produces a coke which would need special care in marketing, especially if the undertaking produced coke of an entirely different character, such as vertical coke.

There remains, however, the possibility of amalgamations of gas undertakings in the populous Northern areas which might provide undertakings of sufficient size to install large oven plants, but the proximity of colliery oven plants complicates this suggestion, while at the present time there are legislative difficulties to be overcome.

Taking a wide view, the opportunities for installing ovens in British gas-works would seem to be distinctly limited unless circumstances, such as those connected with markets for the type of coke produced, effect a radical change in the present conditions.

THE COKE OVEN AND COLLIERIES.

The connection of the coke oven with the essential provision to industry and to the community of metallurgical coke and town gas having been considered, there remains the possibility of employing this type of plant purely as a coal processing plant. In this light it may be looked upon as an upgrader of the raw coal—yielding products (gas, coke, tar, ammonia, benzole, &c.) which together will provide the undertaker with a profit upon his enterprise if sold in suitable markets. Such markets may not necessarily be the usual ones associated with the products—the use of the gas as the starting point of synthetic chemical processes is an example of this. Free-lance plants of this character are already established in America, Canada, Belgium, and elsewhere.

During the early association of coke ovens with collieries in this country, as has been noted, inducements were necessary to introduce the recovery of the bye-products, tar, ammonia, and benzole. Later, however, bye-product recovery was recognized as making a considerable contribution towards reducing the cost of coke production. More recently the ability to secure enhanced gas yields has offered still further remuneration, provided suitable markets can be obtained.

The prices at which collieries can transfer coal to their ovens are in general lower than the corresponding prices they charge for gas coal of identical quality. This is related to the size of the coal in question. Lump coal is needed by gas-works and other users, and hence the demand is good, while slacks are in general considered to be of little value, although quite suitable for carbonization in ovens, so that the demand and the value are low. In Table VII., column 3, an average transfer price of 10s. has been assumed, but many ovens secure slacks at lower prices than this. Nevertheless, it is seen that at 10s. per ton the process of coking can be profitable without any return from the gas. It is obvious, therefore, that the coke oven is a desirable adjunct to the coal industry if the gas can also be marketed remuneratively.

Unfortunately our iron and steel industries, no less than the coal industry, have been depressed owing to over-production in other parts of the world. There has been in consequence a falling-off in the demand for metallurgical coke. Undismayed, coke oven owners have entered coke markets outside their original scope and with a considerable amount of success. In Tables VIII. and IX. the extent of this incursion is shown.

TABLE VIII.—*Metallurgical Coke Production in Great Britain.*

Year.	Total Oven Coke Made.	Oven Coke Used at Blast Furnaces.	Oven Coke Exported.	Oven Coke Used at Foundries (Est.). (Not to Exceed)	Oven Coke Sold for Domestic and Industrial Purposes (by Difference).
	Tons.	Tons.	Tons.	Tons.	Tons.
1908. .	11,153,535	9,746,000	795,000	600,000	12,535
1913. .	12,798,996	11,036,000	823,000	600,000	339,996
1918. .	13,121,311	11,286,680	611,000	600,000	623,631
1923. .	13,418,314	8,645,700	2,745,905	600,000	1,426,709
1928. .	11,845,210	7,616,000	1,597,745	600,000	2,031,645

TABLE IX.—*Sales, &c., of Coke by Gas and Coking Industries.*

Year.	Oven Coke Made.	Oven Coke Used at Blast Furnaces.	Oven Coke Exported.	Oven Coke Used at Foundries (Est.).	Oven Coke Sold for Domestic and Industrial Purposes.	Gas Coke Made.	Gas Coke Used for Water Gas.	Gas Coke Exported.	Gas Coke Sold for Domestic and Industrial Purposes.	Total Coke Sold for Domestic and Industrial Purposes.	Percentage of Gas Coke in Previous Column.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
1923 .	13,418,000	8,646,000	2,746,000	600,000	1,427,000	11,508,000	907,000	1,224,000	7,543,000	8,969,000	84
1924 .	12,753,000	8,609,000	1,848,000	600,000	1,696,000	12,086,000	976,000	965,000	7,419,000	9,115,000	81·5
1925 .	11,009,000	7,466,000	1,222,000	600,000	1,721,000	11,833,000	1,153,000	889,000	7,397,000	9,118,000	81
1926 .	4,715,000	2,956,000	376,000	500,000	883,000	11,598,000	1,436,000	387,000	6,971,000	7,754,000	90
1927 .	11,837,000	8,404,000	807,000	600,000	2,026,000	12,364,000	1,035,000	995,000	7,591,000	9,617,000	79
1928 .	11,845,000	7,616,000	1,598,000	600,000	2,031,000	12,216,000	979,000	996,000	7,699,000	9,730,000	79·2

From this it is seen that some 20 per cent. of the capacity of the coking industry was operating in 1928 for no other purpose than as coal processing plant, the coke produced entering markets which could have been supplied by the gas industry had that industry not exported or converted to water gas a portion of its own output of coke. With modern ovens this 2 million tons of coke which was sold in the domestic and industrial markets would have been accompanied by 20,000 or 33,000 million c.ft. of gas, according to the method of firing, whether by coal gas or weak gas. The desire of coke oven owners to find a remunerative market for such gas, as a return for any enterprise in replacing coke ovens of older types with up-to-date installations, is thus explained.

The most obvious market for gas is that already developed by the gas industry, just as a market for coke production surplus to the requirements of the iron industry was found in the domestic market developed by the gas industry.

As the ovens engaged upon this upgrading of the small varieties of coal are operated in connection with collieries it follows that, so long as they can be supplied with coal at prices less than the prices which gas-works are charged for coal equal in quality, oven gas can be offered to gas undertakings at prices which at present may be below their own costs of production. Especially will this be the case if due consideration is not given to the rigid maintenance of continuity of supply. By maintenance of coal stocks, of stand-by plant, the provision of gas storage, attention to welfare of operatives, and duplicate main systems, the gas industry has secured an unassailed position in regard to continuity of supply, but at a cost which is necessarily reflected in the cost of the commodity.

In an effort to restore the position lost by her as a result of war, Germany some years ago introduced intensive mechanical mining methods in the Ruhr. Unfortunately,

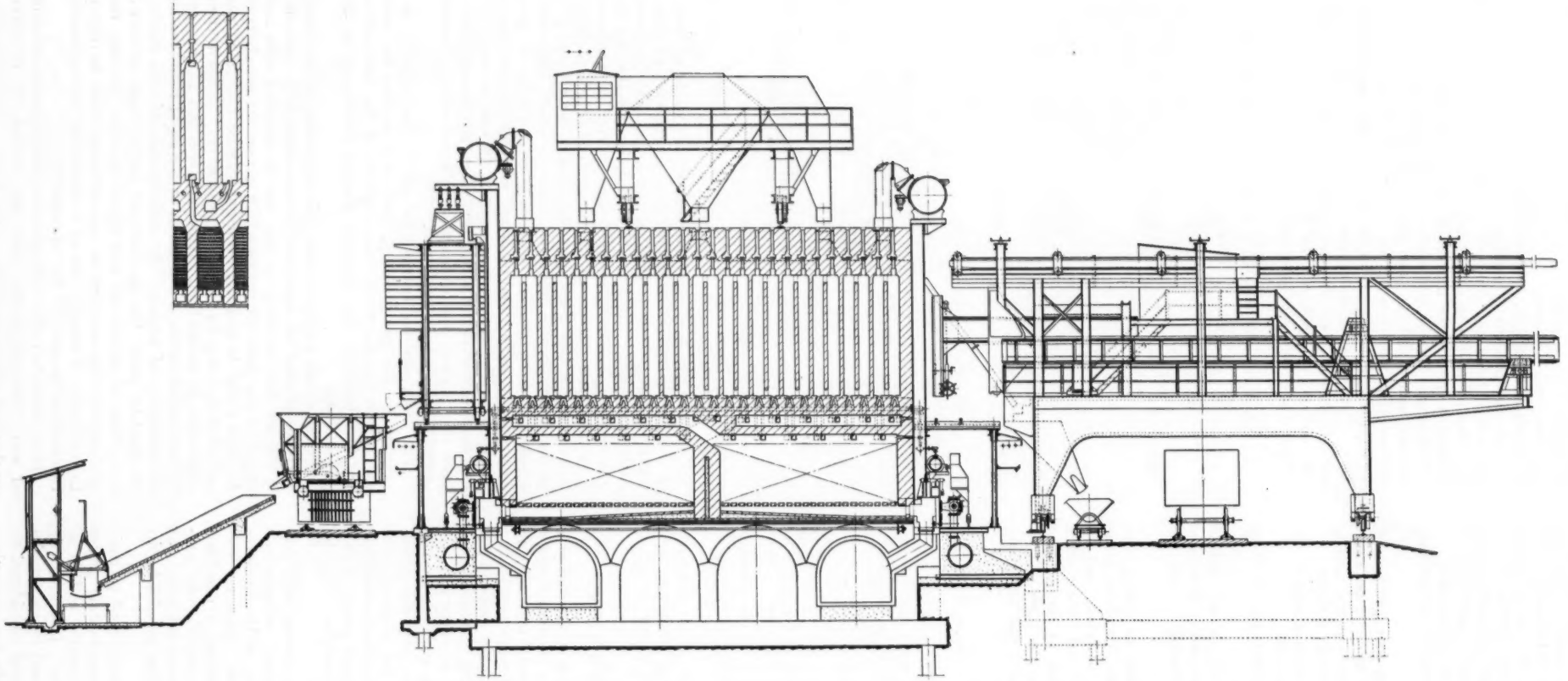

FIG. 5.—CROSS SECTION OF KOPPERS COMBINATION CIRCULATING OVEN.

as with many technical improvements, the maximum results were not achieved. Although mining costs were reduced, the amount of dust and smalls produced was increased to 68 per cent., and the average value of coal won was scarcely altered. A solution of the difficulty was seen in the use of the coke oven as an upgrading process. Some 40 installations of ovens, of capacities between 2000 and 4000 tons of coal per day, were installed, embodying the latest improvements. The financial condition of the country helped in wiping out the capital of old type plants displaced, and the new plants were built with capital borrowed from America. The somewhat increased quantity of coke produced, amounting in all to nearly 30 million tons annually, has so far been marketed successfully, about one-third being exported, where it has not only caused gas-works in other countries to erect ovens to meet it in competition, but has had an effect upon the exports of British coke.

Already it is claimed that the reconstruction has enabled 70 per cent. of Ruhr collieries to balance their losses by the returns on their associated coke ovens. The increased production of gas, however, has led to a new problem. Some 400,000 million c.ft. of gas is produced annually, and even if the ovens be fired solely with coal gas, which is not entirely the case, 240,000 million c.ft. is available for other uses. The total consumption of town gas in Germany is 110,000 million c.ft. per annum. It is obvious that this "glut" of surplus oven gas, if not carefully controlled, would lead to extremely low prices being obtained for it, and, indeed, might result in its being a serious competitor with coal itself, to the detriment of the mineowners. The Coal Syndicate, therefore, formed an Associated Company, now the Ruhr Gas A.G., to market this gas—to towns and industries by long-distance pipe lines, to associated steelworks, unattached to ovens, and to chemical works for hydrogenation, synthetic products, &c.

Much has been written in Germany and elsewhere on the proposals of this Company, which has apparently succeeded so far in remuneratively disposing of only 35,000

million c.ft. per annum out of the vast total. The economics of the proposal have been explained most meticulously, but the underlying reason seems still to be the prevention by concerted action of "glut" prices while making every endeavour to secure the best of the higher priced markets. However one looks at the schemes of the Ruhr Gas A.G., it cannot be denied that they are conceived with masterly skill and brilliant imagination. It is not to be wondered, therefore, that they have received the commendation of the coking industry in this country, the approval of the National Fuel and Power Committee, and may be considered as having ultimately resulted in the setting up of the Area Gas Committee to consider the question of a gas network in the Yorkshire and Lancashire areas.

The British gas industry has always shown itself ready to take immediate advantage of conditions which will benefit its consumers. It is not with surprise one realizes that, by mutual arrangement with collieries, supplies of coke oven gas comparable with the sales for town's purposes of the Ruhr Gas A.G. have already been negotiated, and these supplies are of more significance, as they form a very much larger proportion of the total oven gas available. This is, however, apparently not as rapid a progress as many coke oven owners would wish. Many of our ovens must be replaced as soon as money will allow. To take advantage of modern progress the old small unit per colliery must be abandoned, and the new ovens erected at some central point. Freedom in regard to site is assured, as ovens need not, as have gas-works, be erected on land scheduled after lengthy proceedings in Parliament. This concentration, however, draws attention to the disposal of surplus gas, the quantity of which will, in addition, be considerably increased with new plants. It is claimed that unless the gas be disposed of in a remunerative market—*i.e.*, for town gas or certain industries—such reconstruction cannot take place and progress will be impeded.

For the past two years, therefore, efforts have been made to speed up the sale of oven gas by attempts to force the hand of the gas industry or to secure business which it ought to serve if it were not for legislation affecting its methods of charge. The claim that remunerative gas disposal is essential to pay for the cost of reconstruction does not seem to be of real importance when viewed in the light of the calculation given in Table VII. It rather seems that in England, as in the Ruhr, the modern coke oven is now appreciated as an instrument for the better disposal of the lower priced coal smalls.

If this be the case, the question of surplus oven gas is one to be considered under two categories:

(1) When the resulting coke is intended for ironworks use and the gas is to be sold in preference to use at the steelworks, because of location or for economic reasons.

(2) When the resulting coke is intended for sale in the domestic or industrial market, and the sale of gas is intended merely to aid the colliery or oven owner to take advantage of such circumstances as derating, the absence of legislative control and liability, and the ability to decide coal prices—in effect, to undercut gas undertakings in gas prices and depress them as a result of the lowering of coke prices by overloading the market.

In the second case the situation is seriously affected by the increased production of coke from coke ovens as compared with the normal practice of the gas industry. Gas supplied from gas-works is usually accompanied by ½ to ¾ cwt. of coke to be sold for each 1000 c.ft. produced for sale. The supply of this quantity of gas from a coke oven plant necessitates, however, the disposal of between 1½ and 2½ cwts. of coke, *that is, 3 to 4 times the previous quantity*. Such a change of conditions could not take place without much disturbance to the coke market and, by reaction, to the cost of gas production at gas-works far removed from the locality of the ovens.

The ability of coke ovens to provide a suitable supply of gas for bulk purchases by gas undertakings would appear to need no proof to-day. The economic question as to a fair price to the manufacturer, and a satisfactory form of contract between the parties, have been thoroughly discussed and understood, even if complete agreement has not been reached. The questions of continuity and security of supply, with perhaps the exception of labour difficulties, are simple of solution, if the oven owner will appreciate the motives of gas undertakings in following the experience and traditions of a century and a quarter. The ownership and management of a network of trunk mains still needs definition, but, in view of the powers already possessed by them, the best solution would seem for this to be in the hands of the larger gas undertakings and the mains operated as an extension of their existing systems. The problem is to them no more difficult than is the distribution system of the Gas Light and Coke Company with its area of 460 square miles. Such undertakings could be given additional power to supply the small gas undertakings around them, to operate mains in their areas of supply, and to receive gas into the network from other efficient gas-works.

CONCLUSION.

The functions of coke ovens in relation to the iron and steel industry, the gas-works, and the colliery have now been examined. It has been shown that, by suitable location and balancing of works, the coke oven engaged in the production of coke for iron and steel manufacture need have no surplus gas disposal problem. It has also been indicated that such conditions are not easy of attainment for some years, need the formulation of a definite future policy, and that the location of new ovens in suitable situations ought to receive the most serious consideration. On the other hand, conditions can arise where oven gas can be used more remuneratively than at steelworks. As an item of gas-works plant the oven has been demonstrated to be no better than the continuous vertical retort, which now furnishes 60 per cent. of the coal carbonizing capacity of the industry, besides being unsuitable in size for all except the very largest undertakings. At the same time, the influence of a local demand for hard coke was emphasized.

There can be no disadvantage to the gas industry in purchasing surplus oven gas, provided prices and conditions are right, made in the course of the production of metallurgical coke. Where, however, the coke is intended for the markets already developed by the gas industry, it is obvious that any receipts from the gas accompanying the coke will place the oven owner in a still better position to secure more of the gas industry's coke trade. This situation can only be solved by agreement with the coking industry upon the question of coke sales, brought about by such attention to the quality of the coke produced by the gas industry as will foster the desire for agreement. There is the further point of view that the entry of the coke oven as a purveyor of domestic gas and coke is taking away profit from the collieries now selling coal to gas undertakings and substituting it by a profit made at another colliery operating the ovens. To this extent the coke oven becomes a weapon of competition between collieries.

Finally, it should be borne in mind that the use of our good quality coking slacks *for purposes other than the production of metallurgical coke* has been deprecated as being a serious waste of national resources and not in the future interests of our iron industry.

In presenting this discussion of the rôles which can be played by the coke oven, and the consequential effects, it is realized that questions affecting the economics of five of our greatest industries have had to be considered in a necessarily brief manner. It has been necessary, too, to examine the possibilities and results of other relations between the iron and steel industries and coking and colliery operations than those usual in this country; this has been done purely for explanatory purposes, and with no intention of criticism. It was essential, however, to take this wide view, as in no other way did it seem possible to appreciate properly the reasons underlying the disposal of "surplus" oven gas and coke.

The more intimate details, as between buyer and seller, concerning the purchase of oven gas have not been considered, as they have already been admirably presented before the industry, notably by Messrs. J. K. Dickie, R. Halkett, T. Hardie, T. P. Ridley, and Dr. E. W. Smith. The coke disposal problem, which has been so much emphasized by Sir David Milne-Watson, is one which will

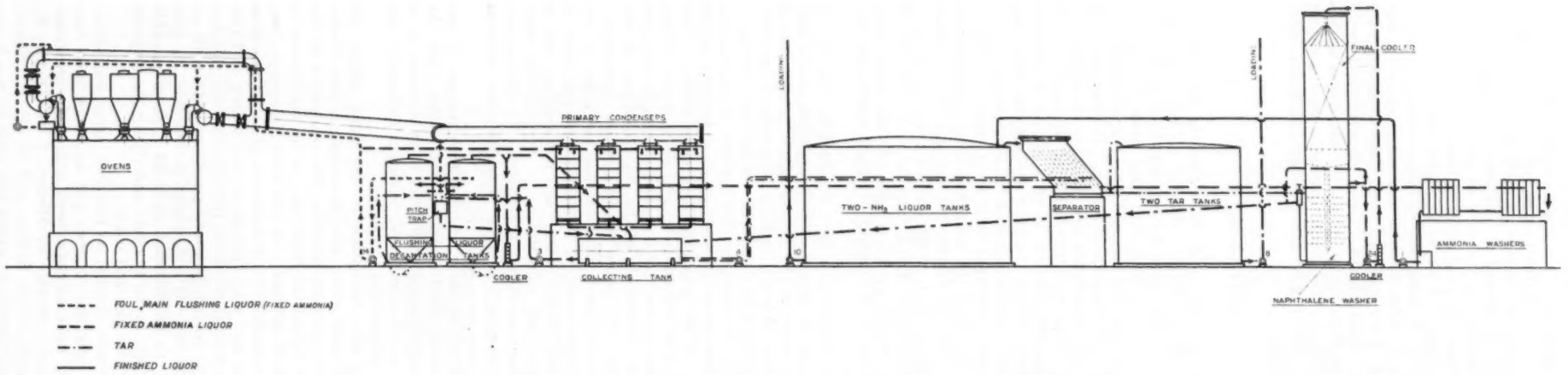

FIG. 6.—TAR AND LIQUOR CIRCULATING SYSTEM.

need considerable attention and action by the gas industry in the near future. The whole subject is submitted as being of vital interest to our industry at the present time, and one which may affect the future policy of every undertaking in the country, irrespective of its distance from colliery areas.

The author is indebted to the Governor and Directors of the Gas Light and Coke Company for permission to present this paper, and, indeed, to them for the opportunities he has had of visiting many plants in England and on the Continent during the past five years, which have provided the first-hand information embodied in the paper.

He also takes this opportunity of thanking several professional colleagues for their assistance and advice.

APPENDIX.

Reference has frequently been made to "modern coke ovens." As an illustration of the intention of this phrase a brief description follows of the installation of coke oven plant now being erected at the Gas Light and Coke Company's Beckton Works, which should be in operation by the summer of 1931. The unit being constructed has a capacity of 1200 tons of coal per day, but is arranged for convenient extension. The reasons underlying the choice of this capacity have already been indicated.

The design was selected to conform to the following principles:

(1) Suitability for production of a maximum yield of coal gas.
(2) Reliability in operation equal to other forms of carbonizing plant.
(3) Ability to prepare coal charge so as to secure best quality coke.
(4) Embodiment of latest practice.
(5) No untried innovations.

The site chosen for the installation was entirely virgin ground and the lay-out has been so arranged that the plant can be extended to an ultimate capacity of 4800 tons of coal per day—that is, two units of 2400 tons per day. The plan of the present and future installations is given in Fig. 1.

The complete site has an area of 78 acres.

Coal Handling and Preparation.

Coal can be received from two sources:

(*a*) By works railway from overhead viaduct; this will be mainly stored coal.
(*b*) By belt conveyor, 1300 ft. long, from near the coal unloading pier.

In the first case, trains consisting of sixteen 5-ton wagons—*i.e.*, 80 tons of coal in all—discharge into a line of hoppers situated below the viaduct, of 210 tons capacity. The coal is fed by roll feeders, situated at the base of these hoppers, on to a belt leading to the crushing plant.

In the second case, the freshly unloaded coal is conveyed directly from the 2000 tons per hour unloading pier by belt conveyors to the crushing plant.

The incoming coal, as received from the railway hoppers or unloading plant, passes first through a Bradford breaker 12 ft. diameter and 17 ft. long, where it is reduced to 1½ in. cube and all unbreakable matter such as tramp iron, wood, rags, &c., removed. It is then crushed in one of two Pennsylvania hammer mills so that 80 per cent. is under ½-in. cube.

The crushed coal is next conveyed to a blending plant consisting of three 200-tons capacity blending bunkers, beneath each of which are four revolving feed tables adjustable in rate of delivery. The twelve feed tables deliver to a sequence of inclined belt conveyors which finally deposit the crushed and blended coal into the central coal storage bunker. This bunker, as are most of the buildings and bunkers connected with the plant, is constructed in reinforced concrete. It has a capacity of 3600 tons of coal (three days' supply) and is divided internally into three compartments. It is situated between the two oven batteries and the lower portion of the structure is used for mess rooms, offices, control rooms, &c. The coal is drawn from this hopper through a set of eighteen doors into the charging machines, which travel on the top of the batteries.

The coal plant throughout has a capacity of 200 tons per hour, the rubber belt conveyors run at between 295 and 320 ft. per minute, and are so enclosed as to prevent dust arising.

Figs. 2 and 3 are cross-sections at right-angles through the plant, while Fig. 4 is a perspective representation of the completed plant.

The Ovens (Fig. 5).

The ovens are Koppers combination ovens of the circulation type with cross-over regenerators. This type of oven combines the following fundamental features:

(1) A solidly built structure obtained by the use of binding walls extending without interruption the whole height of the battery.
(2) The employment of regenerators which are so designed as to avoid the existence of differences of pressure separated by walls of large surface area. In this way cracking of the division walls between the regenerators should not lead to injurious short circuiting.

(3) The use of a circulating device in the heating flues of the ovens so that uniform coking of the contents of the chamber can be secured without overheating the oven top. This also improves the coke quality and reduces fuel consumption.

(4) Ease of regulation and equality of paths of the heating gases.

The installation consists of 60 ovens arranged in two batteries of 30 ovens each. Each oven has a coal capacity of 15·83 tons and is designed for a carbonizing duration of 19 hours, giving a daily throughput of 20 tons. This is based on the use of Durham coal of 7-10 per cent. ash and 2-3 per cent. moisture, and a yield of gas is expected of 85,200 therms per day, as 15,490,000 c.ft. of 550 B.Th.U. gas (before benzole washing). The temperature in the heating flues is 1400° C.

The ovens have an over-all length of 41 ft. 10 in., or between door faces 39 ft. 3 in. Their height is 14 ft. 1½ in. and the average width 17¾ in., with a taper from charging to discharging side of 1⅛ in.

The ovens are arranged to be heated normally by clean producer gas, and in emergency by coal gas. For this purpose nine mechanical revolving grate producers 8 ft. 6 in. internal diameter (one of which is spare) with boiler jackets are provided. Breeze below 1¼ in., and of a combined ash and moisture content of 30 per cent., can be gasified at the rate of 168 tons per day. The plant is installed in a reinforced concrete building incorporating the machinery room, and a fuel service bunker of 600 tons capacity.

For securing the best results in the gasification of small and inferior fuel the breeze is stored, and fed to the producers in two grades—viz., 0 in. to ⅝ in. and ⅝ in. to 1¼ in.

The gas is scrubbed, cooled, and delivered to the ovens under pressure, after measurement of volume and quality, cold, and containing less than 2½ grains of dust per 100 c.ft. The ovens are fired on the usual half-hourly reversal system, the valves being changed over automatically. The spent heating gases leave at a temperature of under 300° C. to a stack 9 ft. diameter 220 ft. high.

Oven Operation.

Coal is charged through three charging holes, situated in the roof of each oven, the centre one being 18 in. diameter, and the two outer holes 14 in. diameter. This arrangement incorporates means for the elimination of smoke and dust. The filled oven is then levelled by a leveller carried on the ram machines so as to leave a free space about 1 ft. deep.

Coke Handling.

When carbonization is completed, the coke is discharged from the ovens by a ram machine of the portal type. The rams, as are all the oven machines, are in duplicate, one acting as a stand-by. They weigh 106 tons each. The pushing speed is 60 ft. per minute, and 80 B.H.P. is required to move the coked charge. The coke passes through a travelling coke guide into a hot coke wagon 50 ft. long holding 12 tons of coke, fitted with doors operated by compressed air. The hot coke wagon is propelled by an electric locomotive (80 H.P.) to a quenching tower which adjoins the central coal storage bunker. The quenching tower is constructed in concrete, formed with basalt chippings. The coke is quenched for a definite period of between ¾ and 1½ minutes, and is then taken to, and discharged on, an inclined wharf 160 ft. long faced with cast-iron plates, whence it is fed through gates to the conveyor leading to the works central screening and grading plant. The quenching can be regulated so that the moisture in the coke at no time exceeds, in coke above—

2 in.	2 per cent.
1½ in.–2 in.	6 ,,
¾ in.–1½ in.	12 ,,

The wharf can hold, simultaneously, the discharge from six ovens. The quenching water passes through a breeze removing plant, and is returned to a 15,000 gallons capacity overhead tank on the tower.

Gas.

For the better production of gas as regards both yield and quality, the ovens are equipped with a gas offtake at each end, 16 in. in diameter. These lead into steel ascension pipes, lined with firebrick, fitted with sealing valves. The ascension pipes feed foul gas mains, 48 in. in diameter, which later join to form a common main 60 in. in diameter leading to the primary coolers. Fixed ammoniacal liquor to the amount of 45,000 gallons per hour is circulated over the foul mains.

TAR AND AMMONIA RECOVERY.

The gas leaving the ovens passes by an overhead main to the condensing plant. The flushing liquor and condensed tar are separated in two receiving and separating tanks equipped with pitch traps. The gas then divides into two streams and passes through four water cooled primary condensers having a total cooling surface of 18,000 sq. ft.; from these it passes through the tar extractors of which there are three, one being a standby. The extractors are of the " P. & A." type, 6 ft. in diameter. After this the gas is pumped by one of the two turbo exhausters which are situated in a combined exhauster and pump house 120 ft. long by 50 ft. wide by 30 ft. high. These are single-stage star-type machines running at 9560 R.P.M. and handling 750,000 c.ft. of gas per hour (measured at N.T.P.) with a suction of 16 in. and against a pressure of 70 in. The turbines are condensing, and develop 335 H.P. each. The exhausters also function as final tar extractors. Leaving the exhauster house, the gas is passed through the final coolers. There are two of these, one being a stand-by. They consist of towers 12 ft. 6 in. in diameter and 73 ft. high. The upper portion of each is filled with wooden hurdles down which cold ammoniacal liquor is pumped in direct contact with the gas. In the lower portion of the tower is an arrangement of perforated plates wherein the liquor is washed with tar for the removal of naphthalene, after which it is cooled and pumped over again.

For final removal of ammonia there are provided three rotary washer scrubbers each with twelve chambers 10 ft. in diameter. The system of ammonia removal by the use of fractionally condensed ammoniacal liquor, described by Mr. Hollings to the Institution in 1928, is adopted. Fig. 6 is a diagram of the tar and liquor circulation systems.

All water cooling is done by means of cooling frames, of which there are three. All main pumps are electrically driven, but have duplicate steam stand-bys.

The washers are electrically driven. The whole of the condensation and ammonia plant is erected on platforms 10 ft. above ground, and no flue or main is below ground level, to avoid risk of flooding from the river.

The gas is purified from H_2S in a range of 32 purifiers (8 sets of 4) 35 ft. by 30 ft. by 5 ft. 6 in. constructed in reinforced concrete. The boxes are above ground. Above them is a travelling oxide raising and distributing plant. All oxide at Beckton is prepared in a central plant.

After purification the gas is measured in station meters and passes to the central naphthalene and benzole scrubbing plant, treating 75 million c.ft. of gas per day. The tar storage for the oven plant is 400,000 gallons and liquor 1,200,000 gallons; these products are pumped to the Company's Products Works, adjacent, for treatment.

The plant is distinguished from many of its coking industry prototypes by:

(1) The more elaborate coal preparing and blending plant.

(2) The self-sealing doors, double offtakes, and smoke prevention arrangements.

(3) The provision everywhere of duplicate machinery, in addition to such aids to repair as ram changing station, cranes on the coal storage tower, and travelling cranes in the machinery houses.

(4) The complete stand-by system, steam driven, to all electric drives. Where a steam drive is impracticable, a power supply is provided from a special stand-by turbo alternator.

(5) The rates of flow in the various mains are slower than is usual in coke oven practice, being, as far as possible:

Gas	10 ft. per second
Live steam	100 ,, ,,
Exhaust and steam	65 ,, ,,

	Reciprocating Pumps.	Centrifugal Pumps.
Water and liquor—		
Suction	5 ft. per sec.	6 ft. per sec.
Delivery	6 ,, ,,	7 ,, ,,
Tar—		
Suction	4 ,, ,,	5 ,, ,,
Delivery	5 ,, ,,	6 ,, ,,

(6) The very complete arrangements for the measurement of flows, temperatures, pressures, and power.

(7) The provision of a producer gas plant as the principal means of heating the ovens.

It will be noted that these features are normal to gas-works plant and are necessitated mainly by the obligation to secure absolute reliability in operation and continuity in output under all circumstances.

The main contractor for the whole of the plant up to the outlet of ammonia washers, exclusive of the foundations, is the Koppers Coke Oven Company, Ltd., Sheffield, to whom the author is indebted for permission to publish Fig. 5.

DISCUSSION.

The PRESIDENT: Mr. Stewart is to be congratulated on the masterly way in which he has treated his subject, and he can feel satisfied that he has considerably clarified the positions of both gas undertakings and coke oven interests in regard to the disposal of " surplus " oven gas and coke. The survey of American and German coke oven practice, and the comparison with conditions that exist in Britain, enable us to visualize the lines upon which future development must proceed in this country; and the part that the gas industry could play is clearly indicated.

It has been shown on economical grounds that for individual works, except in about four cases, coke ovens as a gas-

making unit can be ruled out. The position is altered, however, where the possibility of a combination of undertakings exists. After reading this paper one must feel convinced that in the interests of both the coke oven producers and the gas undertakings it is necessary for some mutual understanding to exist in regard to the marketing of their respective bye-products. Take the case of coke as an example, the gas industry makes some effort to maintain prices by consuming its own commodity for heating retorts and also the manufacture of water gas; this sacrifice benefits the coke oven interests and indirectly strengthens their competitive power in the coke market.

Mr. Stewart also points out that where coke oven gas is being purchased by gas undertakings from coke ovens supplying coke to the same market and competitive with gas coke, the price paid for the gas helps to reduce the charges on coke production; and this again gives the coke ovens an economic advantage in the competition for coke sales. This is a result which would affect not only the undertakings involved, but many others, and shows the necessity for approved action in these matters.

Finally, I would like to congratulate the Gas Light and Coke Company on the very comprehensive scheme of coke oven plant being erected at Beckton. The arrangements made to ensure continuity of working in all emergencies, and the adoption of putting into practice of the valuable knowledge obtained in their Research Laboratories, command the admiration of us all, and typify the ability of the Gas Light and Coke Company to handle successfully the biggest of schemes should the opportunity present itself.

A Lesson for the Gas Industry.

Sir ARTHUR DUCKHAM, G.B.E., K.C.B.: I think we should all like to congratulate Mr. Stewart on his very full, interesting, and instructive paper on coke ovens. It is one of the first papers of its type that we have had presented to the Institution of Gas Engineers from the gas point of view. As I am interested in coke oven work as well as retort work, I think I can speak without any prejudice in this matter. In the paper, Mr. Stewart claims certain advantages and certain disadvantages for coke ovens; and in looking through these one must bear in mind that the coke oven has been developed for one principal purpose—the manufacture of coke. He has the advantage of low labour cost; this is due very largely to the large size of plant. He speaks of low fuel cost, but I think that with a modern retort setting, with waste-heat boilers, the thermal efficiency is very much the same as that of the coke oven plant, and under certain conditions possibly the retorting plant can give better fuel results. He speaks of the long life of the coke oven as being due principally to the fact that it is maintained at one constant temperature throughout its life. We all know that one of the reasons for the shorter life and the higher maintenance costs of gas-works plant is that there has to be a variation in the output of the gas-works as between summer and winter, and that there is consequently the changing of heats in the gas-works plant, or the entire extinction of heat. On the other hand, in practically all cases it is not feasible to allow the coke ovens to go out of production; and I think we in the gas industry might take a lesson from the coke oven people and, for our summer load, devise means of decreasing our production per unit instead of allowing any of the units to go cold, giving rise to troubles from contraction.

I do not quite understand Mr. Stewart's point with regard to coke quality control. As I have said, the coke oven has been developed for the production of coke, and in consequence the greatest study has been given to the question of the quality of the coal used in the coke oven and the control of coke quality. I do not know whether he means that coke quality is controlled by varying coals or possibly the length of time that the coal remains in the oven for coking. It is not a paying proposition for a gas-works to put in coke ovens unless they can obtain a superior price for their coke. If they are going to obtain a superior price for their coke, they have to copy the coke oven users' practice, and employ suitable coal, and clean coal. To-day the price of oven coke is below the price of gas-works coke. Oven coke is selling at 17s. 4d. f.o.b. on the Tyne; I can buy oven coke at my house in Surrey at a lower price than I can buy gas-works coke from the local gas-works. Therefore, unless you have a right coke market for your coke, it is of no advantage to a gas-works to put in a coke oven plant. I would stress the point that if we in the gas industry pay the same attention to our coal as do the coke oven people, if we can give our consumers 91 per cent. of carbon in the coke we deliver to them, instead of possibly 75 per cent. of carbon, the price of our coke will remain high. I do not think there would be any great advantage in having coke ovens on a gas-works except in cases such as Beckton—where there is a special market for the special coke available—because the coke oven is not as economical a gas producing unit as a modern retort plant. After all, we are a gas industry whose purpose is to make gas at the cheapest price and to deliver it under the best conditions; we are not primarily coke manufacturers.

Small Ovens in America.

Mr. G. M. GILL (London): Mr. Stewart is to be congratulated on his exceedingly lucid and complete summary of the functions of coke ovens from the point of view of gas undertakings. Naturally, there are points on which we may not agree with him; but with the great majority of his conclusions I, like the rest of us, am certainly in agreement. I rather gather, as the result of reading the paper, that he does not include within the term "coke oven" the smaller ovens which are used so largely in many of the gas-works in the United States. In the earlier part of the paper he speaks of the large use of coke ovens by gas undertakings in America, in Germany, and on the Continent of Europe generally. In America particularly you will find they are using the smaller ovens, holding charges of from 4 to 6 tons; and these installations are fitted up in precisely the same manner as a modern coke oven plant. It has always seemed to me, from my examination of these systems, that this smaller type is really very suitable for gas-works, because it is a type of plant which can deal with coals such as cannot be dealt with to advantage in a continuous vertical retort system. They will make good coke from very fine slacks. Of course, Mr. Stewart did not deal with every type of oven, but I do suggest that in the direction I have indicated there is scope in this country. It is shown in the paper that the coke oven is at a disadvantage from the point of view of ground space; but Mr. Stewart is basing his figures on the wide oven—having a width of (say) 18 in.—and his comparison would be somewhat different if he substituted the narrow oven which is so extensively used in the United States. The ovens in the large gas-works there have an average width of about 14 in. and a carbonizing period of 12 hours. With these narrower ovens, as compared with the wide ones, there is a marked difference in the amount of gas that can be made on a given area. Again, in other places, notably at Rotterdam, they are making a lot of gas in a small coke oven in which is used hinged pusher rams. In an old retort house they have built ovens having pushers with hinged rams; and in this house they are making considerably more gas, I believe, than they could with the horizontal retort system. As regards the type of coke, I sometimes think the idea that we cannot sell oven coke is something of a bogey; I believe that if we had to sell oven coke we could do so with advantage. We talk of wanting an easily combustible coke, but in the gas-lighted grates which are coming into popular use oven coke can very readily be lighted, and when once lighted it makes an excellent fire. If it were my business to have to sell coke, I should not despair at all of building up an excellent market for oven coke, and I do not think that this marketing problem ought to stop us from considering the use of ovens in our gas-works.

In conclusion, I think Mr. Stewart's paper is an admirable one, and fully up to the very best standard of the papers which we are privileged to hear at our annual meetings.

Coke Oven Gas for Town Purposes.

Dr. E. W. SMITH, C.B.E. (London): The Area Gas Sub-Committee, with which I had some connection, had very difficult problems to consider, and the chief problem was whether it would pay the gas industry to buy coke oven gas if it could be collected together in a grid main. Of course, our coke oven friends can get, and have got to date, prices for their gas which were justifiable under conditions in which their gas was to displace domestic gas, and perhaps to be used for industrial purposes which could justify a comparatively high price for gas—a process price rather than an economic fuel price. But when you look into the possibilities of using this gas you find that in the Sheffield area already 46 per cent. of the gas is being used for industrial purposes, at a price which is very low but still not low enough for some industries; and in the whole of the Sheffield area over 75 per cent. of the gas distributed by the gas industry is coming from the coke oven industry already. Yet there is a suggestion that we are behind-hand as compared with Germany in assisting the steel industry and the colliery industry by using, in the gas industry, gas from the coke ovens. Whereas in Germany they are using (say) x amount of gas per ton of coke sold to the metallurgical industries, in England we are using $2x$ of gas per ton of coke employed in the metallurgical industry. To put it in another way, the amount of gas that is being purchased from the coke oven industry in this country is approximately the same as the amount of gas that is being sold by the steel industry in Germany—the amount of coke made in the coke ovens of Great Britain being half of that which is being made in Germany. Thus, we are not far behind. The question was not that of how much is being used, but, rather, Can more be used, and can it be collected and distributed for the use of the gas industry?

In considering the question of cost of distribution it was very quickly realized that unless we had coke ovens reasonably close together, so that the gas could be collected economically, and unless there was an outlet for the gas in a fairly concentrated area, the gas industry could readily produce gas more cheaply than the coke oven industry could supply it—if you in-

clude cost of purification and distribution. So that, if you look at the area that has been considered, you will find that, stretching from Hull to Liverpool and from Leeds to Birmingham, there is only one concentrated area, around Sheffield, in which the gas can be used in big quantities, and where the coke ovens are situated sufficiently close together to justify the collection of the gas from the coke ovens. It is absolutely impracticable to take gas into Birmingham from its nearest coke oven area; distribution alone would cost 4d. or 5d. per 1000 c.ft. Birmingham is making gas at quite a low price, and the gas authority there could make its own gas more cheaply than it could buy gas from the coke ovens. It was also realized that, as 75 per cent. of the gas used in the Sheffield area is already coming from the coke ovens, there is not much of an outlet (for the remainder of the coke oven gas made) within the balance of 25 per cent.—and that 25 per cent. would represent not more than a few millions a day. The coke oven industry wants to dispose of 80 millions a day, and that is a big quantity. While it is easy to make arrangements for the supply of gas from a single coke oven undertaking to a single gas-works to the extent of 3 or 4 millions a day, at a price satisfactory from both points of view, it is another thing to find an outlet for 80 millions at an attractive price. The only further outlet for large quantities is to the steel industry, to displace producer gas, coal, or oil. In order to do that it is necessary that its price should come down to about 2d. per therm. The addition of distribution, purification, and all the other costs would increase the price to something like 10d. per therm, which would give the coke oven people a return of 5d. or 6d. net for their gas of 500 B.Th.U. per c.ft.

There was a difference of opinion on the Committee as to how the grid, which is definitely recommended, should be operated. I personally am strongly of the view that the only practicable scheme is that the Sheffield Gas Company should own the grid. Any other scheme it would take too long to arrange, and would in any case be inequitable. To make the scheme perfectly equitable it was suggested that there should be a large number of reservations and precautions for the protection of the coke oven people, the primary reservation being that there should be separate accounts kept for the grid, and that half of the profits from the grid should go to the consumer (the gas company or companies) and the other half to the coke oven people, thus giving them a bonus on the price arranged between them and the gas company or companies.

Competitions from Coke Ovens in Burnley.

Mr. J. H. CLEGG (Burnley): I think the congratulatory remarks which have been made with regard to this paper meet with the accord of us all. On reading the paper I was impressed with the immensity of the units with which Mr. Stewart deals, and the fact that his paper is based on his experience of dealing with such immense units makes it rather difficult for the average gas engineer to discuss the problems of the different methods of carbonization. As to the class of coke which is produced in the coke ovens, in my experience it is not comparable with the ordinary gas-works coke for domestic purposes. In Burnley we have to meet intense competition from the local coke oven plants and at prices which are 2s. per ton more than our own I find they are not successful in meeting more than 5 per cent. of the requirements of the town. In discussing whether it is advisable to purchase coke oven gas, it must be realized that there is a critical point at which the value of coke begins to decrease. Recently we have commenced to purchase a small quantity of coke oven gas as an alternative to extending our works. In regard to the proposition to extend the works we had to consider the problem of disposing of the extra coke which we should produce, and as the position was such that we should have to export half of the coke we produced, we found that our net receipts would be very low. The coke oven people, in producing the necessary gas, produce about double the quantity of coke which we should have produced, and they cannot possibly find a market in our town. We are able to supply all our customers; and consequently the coke oven people, and not ourselves, are faced with exporting coke at low prices. There may be, and indeed I am certain there is, a demand for furnace coke abroad. The method of consumption abroad is very different from that which obtains in our part of the country. I certainly think that the progress which has been made in the sale of coke in competition with coke ovens is almost wholly a matter of price. Reference has been made to a remark in a paper read by Mr. Leech in 1922 regarding the difference in cost as between the gas produced from verticals and that produced from coke ovens, and he states that there is an advantage amounting to 1d. per therm in respect of the coke oven gas. I think, however, that circumstances will have altered a little since that paper was read. One of the advantages in the production of cheap gas in coke ovens is the fact that the coke oven people extract their benzole, and they derive quite an appreciable revenue per ton of coal from the benzole sales. Perhaps we in the gas-works may improve shortly in that direction, where the possibilities exist. I feel that in comparing the cost of horizontal and vertical gas plant, Mr. Stewart has been as fair as he possibly can be under the circumstances, but there are one or two matters which I would venture to criticize. I do not think it is fair to give a price of 21s. 6d. per ton for coal to be used in the coke ovens, in verticals and in horizontals, because my experience is that we can utilize, in horizontals, coals which cost 5s. per ton less than those used in verticals, and in spite of that we are successful in obtaining 75 therms per ton. This reduces substantially the cost of gas produced in horizontal retorts, and there is the added advantage—which has not been taken into account in the paper—that we are enabled to produce steam with the red hot coke of the retorts. Against this I admit there is further capital expenditure. I secured figures before deciding to erect our own plant, and I found those figures compared satisfactorily with other figures relating to a much larger installation. I certainly agree with the author that the capital costs of the erection of coke oven plant are far too high for consideration by medium size gas-works. The capital costs are so high that there are very few gas-works in the country the owners of which can contemplate the utilization of coke ovens for producing gas at such a price as would in any way compare with the price of gas made by existing gas-works systems of carbonization. I should like to ask Mr. Stewart whether, in comparing the costs of manufacture by coke ovens with the costs of manufacture in other types of carbonizing plant, he assumed the same rates of pay in all cases. I do not wish it to be considered from my remarks that horizontals must necessarily produce gas at a lower price than do verticals. We are all agreed that local circumstances have to be taken into consideration, and probably in the majority of cases verticals will produce gas more cheaply; but in my own particular case I am thoroughly convinced that we can produce it more cheaply by horizontals, particularly having regard to the fact that we have to use local coal. In conclusion, I would express indebtedness to the Gas Light and Coke Company for having installed such a system of ovens. The Company's experience will be of great benefit to the gas industry.

A Monument of Impartiality.

Mr. H. E. COPP (Hull, President-Elect): The paper we have had presented to us is a monument of impartiality, because not only have the advantages of coke ovens been placed before us so clearly, but we have also had our attention called to the disadvantages. It appears from what we have been told that it would hardly pay the ordinary gas undertaking to buy coke oven gas when the costs of gas into the holder are as low as they are in many towns. In cases where a large expenditure on extensions of gas-works is an alternative, of course, there might be a good case for taking coke oven gas, but it rather appears that coke oven gas can hardly be a profitable speculation unless use is made of the capital already employed in gas undertakings. I refer particularly to the capital expended on purifiers, mains, holders, governors, &c. Of course, one of the most important things we have to face nowadays is the cost of distribution. It is continually increasing, and that is the limitation with regard to coke oven gas, in my opinion. We are again very much indebted to the Gas Light and Coke Company for taking such a wide view of the possibilities as to embark upon a scheme of such magnitude as this, because it is necessary nowadays that we should explore all the possibilities of gas-making. Another point we must bear in mind is that the coke oven people very often tell us they can use a lower grade coal. I have no doubt they can; but if you use a lower grade coal, it will be reflected in the quality of the coke. You get back in the coke all the ash that is in the original fuel. I think the quality of coal we are getting is very much purer than it was a few years ago, and that is a thing we have to be profoundly thankful for. Consequently, it is very much to be hoped that progress will continue with vertical retort carbonization. Another aspect of the matter is that a large proportion of our coke must necessarily be exported under present conditions. That is a great pity, because if we could educate our public to the value of coke as a domestic fuel we should have no difficulty whatever in disposing of the whole of our production. Still another point is that the denser the coke, the less useful it is to our Continental friends. One of the great advantages of vertical coke is its lightness. As you are aware, we sell it by the ton in most cases; but they purchase it in bulk, and there is a lot in that, because not only can they use our coke very much better, but they ask for it—and very frequently for vertical coke—for that reason.

Mr. L. H. SENSICLE (London): As far as I know, it is 15 years since the first, and, until recently, the only, coke oven battery was built at a gas-works in this country. Since then, very great progress has been made in the design and operation of coke oven plant. Having been privileged to study the inception of an even more recent scheme of similar dimensions to that described by Mr. Stewart, I should like to offer a few comments on his valuable communication. His summary of the development of coking practice is undoubtedly a favourable one, and from Mr. Stewart's careful analysis, the only conclusion to be drawn is that the decision to instal coke ovens at Beckton was justified. No doubt the first of two main con-

siderations—*i.e.*, "expediency in respect of coke quality"—has previously held undue weight. But the coke oven owners themselves have done much to prove that oven coke can compete successfully with ordinary gas coke in the same domestic market and even gain precedence in the consumers' estimation. The last column of Table VIII. clearly demonstrates this fact.

The growing amount of oven coke now sold in the domestic market is made in ordinary wide ovens, and is, in most cases, of metallurgical quality. It is not, however, generally realized in the gas industry that by building narrow ovens such as have already been tried in the U.S.A.—*e.g.*, 12 in. wide—and so speeding up the carbonization process, coke of a similar character to horizontal retort coke can be made. Incidentally, this is the policy adopted by constructors of intermittent vertical chambers, which are in effect small coke ovens set on end, but of a width of only 11 or 12 in., though occasionally they have been constructed 18 in. wide or more with a view to producing metallurgical coke. It is interesting to note that the Gas Light and Coke Company have decided upon a width as great as 17¾ in.—probably a wise choice. Consumers who are not used to oven coke will have to become educated to its use, and will in all probability prefer it in the long run. But there is a further consideration—no doubt realized by the Gas Company—that they will be able to sell their coke in the metallurgical market should they so desire.

With regard to the tabulated information, Mr. Stewart has supplied a wealth of material for future reference and discussion, and it is only possible to refer to one of two outstanding features. It is noted that in the cost comparisons on Table VII. only three types of gas-making plant are compared—inclined retorts even being omitted—while in none of the tables is there any reference to the intermittent vertical system of carbonization, which would undoubtedly have afforded illuminating comparative data. Mr. Gill has recommended small coke ovens of 4 to 6 tons capacity as suitable for gas-works, and it may be suggested that modern intermittent vertical chambers supply this need while being charged and discharged by gravity—a distinct advantage.

In Table VII. it appears that the calorific value of the gas is not the same in each of the cases considered. For example, the yield of 78 therms per ton from continuous verticals surely indicates steaming down to 500 or lower, while the 71 therms per ton for coke ovens is presumably intended to represent straight gas of over 550 calorific value, there being no mention of benzole recovery.

It is obviously incorrect to make a comparison in this way, and it does not do justice to the coke oven costs. If there is to be steaming of the continuous vertical retorts, then the coke oven gas should be considered as adjusted to a like calorific value. In this connection, I would refer to the case in which it is intended to use producer gas for adjustment purposes. This gas will be drawn from the producers installed for heating the battery, due allowance being made for storage capacity. Such a diluent gas would, as stated by Mr. Stewart, cost only 1¼d. to 1½d. per therm, and would thus serve to increase the balance in favour of the coke oven gas as compared with that from continuous vertical retorts.

Referring again to Table VII., it will be noticed that the same price per gallon has been allocated to continuous vertical retort tar as to coke oven and horizontal retort tar.

In Table V., Mr. Stewart adduces figures to show that coke oven plant produces less gas per square foot of site than all other types, including horizontal retorts. It is understandable that continuous and intermittent vertical plant have greater possibilities in this direction, but it is hardly credible in the case of horizontal retort plant. It is difficult to know what to include in the coke oven ascertainment. Final comment is, perhaps, allowable in regard to the fuel consumption comparisons. It is there shown that if continuous vertical retorts are credited with the heat recovery in the waste-heat boiler, the net heat consumption is lower than for coke oven plant. This is conceivable in view of the fact that in highly steamed vertical retorts a quenched coke can be claimed; but it should be added that new developments in the coking industry, whereby the hot coke is discharged into dry cooling chambers, have been proved to give a heat conservation much superior to the best obtainable in continuous vertical retort installations. As an example, it may be said that a net heat consumption of not more than 500 B.Th.U. per lb. of coal carbonized has been thus obtained.

In his calculations Mr. Stewart has set the lower limit for size of coke oven plant at gas-works as 1000 tons per day throughput. This does not appear to be the opinion in other countries; and from the figures given it can be calculated that, assuming 330 days' working per year, 18 such European plants average 421 tons each, and 24 American plants 757 tons per day each. I would suggest that 600 tons per day is probably nearer the true economic minimum for coke oven plant at gas-works in this country. With regard to the cited disadvantages, experience alone will show whether they have foundation in fact. It is quite likely, for instance, that the gas yield from the coke ovens described will prove superior to that in good horizontal retort practice.

Economic Price of Coke Oven Gas.

Col. W. M. CARR (Stretford): It is inevitable that a contribution such as Mr. Stewart has given us to-day should provoke many differences of opinion; but that enhances its value enormously from all points of view. First of all as to the general initiation of the position with regard to taking coke oven gas commercially. Mr. Stewart says the question arises whether, provided the cost of distribution and marketing oven gas is less than the difference between the value of oven gas to the steel works and its value to the industrial consumer, real economy in iron and steel manufacture cannot also be secured in an equally successful manner by the outside sale of such oven gas. This is a point which, I think, everybody appreciates, from the steel works efficiency point of view; but when we consider the question of purchasing coke oven gas, as gas undertakings, there is another point of view; and I should like to issue a word of warning. We are all inclined to say that if we can get coke oven gas at a price which is lower than the price of our own gas into the holder, it will pay us to buy it; but I would warn you that the cost of our gas into the holder is not necessarily the cost of the additional gas that we might have to make over and above what we are already making. I feel certain that some contracts that have recently been made for the purchase of coke oven gas might not have been made had the proposition been considered not from the point of view of average cost, but from the point of view of what would be the cost of the additional gas where there was surplus plant available in the gas-works.

Each works must be considered on its own merits, because where works have surplus plant, and even assuming that the cost of gas into the holder is as high as 1s. 2d., it does not necessarily mean that coke oven gas at 8d. will be cheaper, because, assuming 30 per cent. increased output could be given by the existing plant in the works, it might be deduced that the cost of making that additional 30 per cent. would be 6d., or less than 6d., per 1000 c.ft. This is the danger of comparisons on figures such as we have had put before us. I should also like to refer to the figure given by the author for the heating efficiency of horizontals. It is a very unfair figure on to-day's practice. A figure of 1875 B.Th.U. per lb. of coal represents ridiculously bad working to-day. With waste heat recovery and carbonizing washed smalls, I am achieving a figure of 820 B.Th.U. per lb. of coal—and this is a figure for a whole year's working. If the figures are corrected to that extent, then the advantage of coke oven gas is not so great as the paper shows. I would not dare to dogmatize as to the plant which is the most suitable, because the circumstances in each locality are different. It happens that I have a market for coke of a semi-metallurgical character to be used for industrial purposes, and my particular plant—which is a horizontal plant with very efficient regenerators and efficient waste-heat recovery—is suitable for that purpose, because I am able to carbonize washed smalls and make a clean coke. Indeed, I have one large contract under which I guarantee to sell coke with not more than 10 per cent. of ash and moisture. This can be done in modern horizontal practice; and if we can produce what I call a medium metallurgical coke for the smelting of non-ferrous metals and that class of work, we can compete with coke oven coke.

Continuity of Supply.

The PRESIDENT: No mention has been made of the very important item of continuity of supply and also of the fact that during the period of contract it is necessary to repair and maintain your plant (otherwise, I am afraid that at the end of the contract period the coke oven people will be in a very much stronger position to enforce a higher price). The cost of the repair and maintenance of plant must be reckoned with in considering the cost of coke oven gas. I should like Mr. Stewart to deal with that point when he replies to the discussion.

The Author's Reply.

Mr. STEWART: I am very gratified by the discussion on the paper, and I really feel that the discussion was more important than the paper itself. Criticisms have been made from three different aspects. As to the first—the matter of technical comparisons between various systems of carbonization—I think I shall have to deal with the main details in the course of a written reply. The labour costs are not coke oven labour costs, but the costs at ordinary gas-works rates. Reference has been made to small ovens and to intermittent verticals, but I did not include in the paper any systems of carbonization other than the more usual ones, because I felt that if I put in too many comparisons I should have given a mass of data which would have served merely to confuse the issue. With regard to the width of oven, we spent a very great deal of time in considering the matter before we decided upon ovens of the width of those we have at Beckton. I think this is one of the most important points we have to go into. With regard to the 12-in., 13-in., and 14-in. ovens, my opinion is that in a large number of cases the users have said that they will never go back to that size because, for one thing, they are very difficult to repair. Also, as we all know, we have to strike a balance between very rapid carbonization, comparatively poor

coke, and good gas yields on the one hand, and slow carbonization and possibly not quite such a good gas yield, but better coke quality, on the other hand. The second matter which has been the subject of criticism is that of coke quality; and I think the remarks of various speakers on the question of whether oven coke is what the domestic user in this country wants cancel each other. I think it depends on the size of furnace and the local conditions, but there is no doubt that the coke oven industry, by its very nature, has given a very great deal of attention to this question of coke quality. Though I believe that the real factor is that of price, we must not forget that the coke oven people study coke and that we study gas, and that continued attention is bound to lead to improvement in the quality of the material. I was very much impressed, when in Sweden a year or two ago, by the meticulous care with which they wash the coke there. They spend as much time testing their daily output of coke as is usually spent in a gas-works on the testing of the quality of the gas. They examine such details as the melting-point of the ash, and so on, in order to ensure that their customers receive a standard product all the time. We are very much indebted to Col. Carr for having reminded us that, when you increase your make of gas, the cost of making that extra quantity is not the same as the average cost of the total; in fact, a slight increase in output enables you to reduce the average cost of the total make very considerably, and the cost of making the extra gas, considered by itself, is really quite small. This brings me to the point raised by Sir Arthur Duckham concerning the summer load and the importance of flexibility. If the conditions in the gas industry were such that we were able to sell gas at very cheap rates at off-peak periods, in the same way that electrical people can sell cheap units at off-peak periods—*i.e.*, when the legislation that controls the gas industry is altered—this question of partial or summer loads will become of very great importance, and then the whole question of the economics of selling gas, buying gas in bulk, and linking up various gas undertakings by means of a grid, will come into prominence.

Experiences with a Waterless Gasholder.

By FRANK PRENTICE, M.Inst.Gas E.,

Engineer and Manager, The Ipswich Gas Light Company.

I suppose every member of the Institution has considered the merits and demerits of waterless holders. To some, increased storage is within their immediate purview; to others it is visualized as a distant contingency. Whatever the position may be, some experiences of the first one erected in Great Britain, extending over rather more than two years, may be worth a few minutes' consideration.

The Ipswich holder has a diameter of 123 ft., is 202 ft. high, and when full contains 2 million c.ft. of gas.

FOUNDATIONS.

The Ipswich works are situated within a few yards of a large dock, and on a site that at one time was the riverside; hence, to obtain suitable foundations for any considerable weight, piling must be resorted to. Our latest retort house is on piles varying from 18 ft. to 35 ft. long, and they are designed to carry 90 tons to the square foot.

With this difficulty fresh in my mind, I welcomed the idea of a holder the erection of which did not necessitate the trouble and expense of piling. The total weight of this holder is 800 tons

The specified foundations are simple, and far less costly than those required for the tank type, because only about one-twentieth of the weight has to be carried.

The result was most satisfactory. Constant watchfulness for many months after erection failed to reveal any trace of subsidence, a state of things that has continued ever since.

PRESSURE.

Some correspondence has taken place in the Technical Press as to whether the claim of constant pressure is valid. Personally, I have never made such a claim. The lifting power of the gas causes a reduction of pressure when the holder is full, exactly as is the case with a tank holder, and, as this applies to all types, for comparison purposes it may be dismissed.

Where the waterless holder scores is in the absence of cups, and the consequent succession of sudden increases or decreases are absent. The importance of this also lies in the fact that during the period of the peak load the maximum pressure a holder will give is usually required; if during this period a drop of from 2 to 3 in. is experienced, due to uncupping, trouble occurs in the district.

All such fluctuations are absent with a waterless holder, and this is a strong point in its favour.

While on this point, may I draw your attention to Fig. 1, where you will see that at 11 p.m. there was 500 000 c.ft. in the holder. From that time to 6.30 a.m. the contents were increased to 1,020,000 c.ft., which increase was due to production exceeding demand; and during this period the lifting power of the added gas slowly and regularly reduced the pressure from 101 tenths to 99 tenths, a drop of 2 tenths for 500 000 c.ft. of added gas.

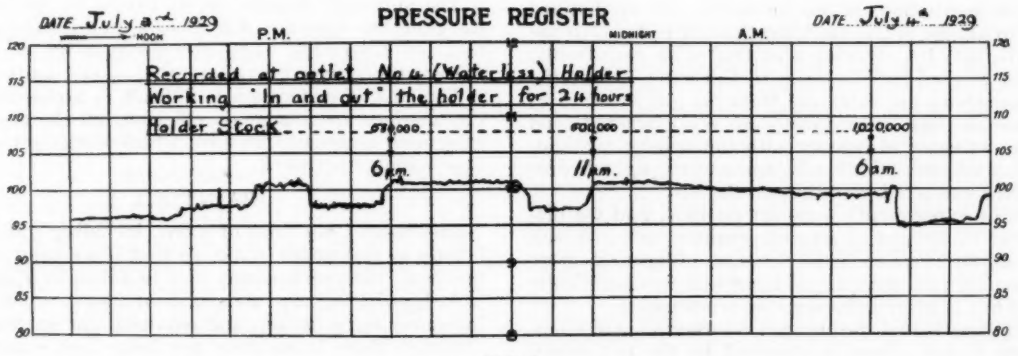

FIG. 1.

Further, you will see certain variations of around 3 tenths; these are due to the direction of piston travel. When the disc is rising, 3 tenths increase is observed, and when the disc is falling the reverse happens.

After examining some hundreds of daily charts I am able to say that in actual practice the maximum variation of pressure recorded is 8 tenths of an inch water pressure.

While considering pressures, it is worth noting how easily they can be increased or decreased in these holders by means of concrete blocks on the disc itself. We started with 10 in. last winter; during the peak load we experienced a shortage at the extreme end of our district, 10 miles away, and to meet this we lowered the disc,

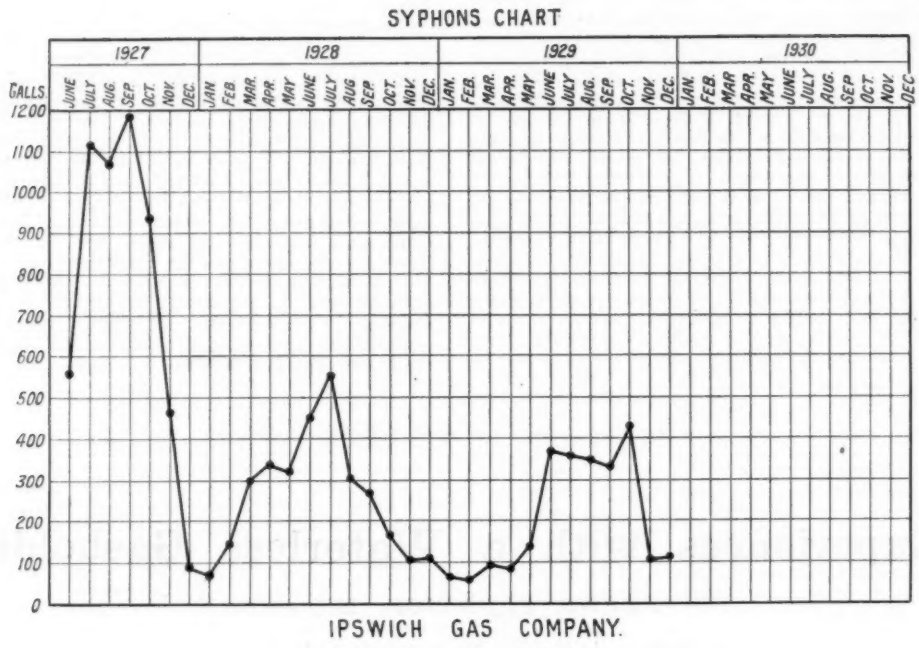

FIG. 2.

opened the man-hole, and slid the required number of concrete blocks through it, and so increased the pressure from 10 to 11 in. with no trouble and very little expense.

SEALING MEDIUM.

We adopted tar for this purpose, and during the first winter considerable anxiety was experienced, because, instead of the tar thickening up under reduced temperature, the reverse happened; the tar got thinner and thinner, and the pump runs increased in consequence. In normal working the runs should be 125 per week, and the units of electricity required about 40. In the circumstances described 1734 runs, and 149 units were recorded in the period mentioned.

Fractional distillation revealed the reason. Light hydrocarbons were being absorbed in large quantities, and the remedy was not immediately apparent.

When we prepared the batch of tar for the seal, we followed the instructions of the patentees, and we distilled crude tar to almost pitch, and then thinned it down to the required viscosity by returning a portion of the middle oils.

This had worked satisfactorily in Germany, where the light hydrocarbons are extracted from the gas before use, but at Ipswich these constituents are not extracted, and where the gas came in contact with the sealing medium, heavily charged with middle oils, some of the light hydrocarbons were extracted, and thinned the tar.

A series of experiments were set on foot, and we discovered that if, instead of returning middle oils to break down the distilled tar, about 10 per cent. of light oils were added, a sealing medium was produced that was practically static, and but slightly influenced by temperature.

What happens is that during cold weather a small quantity of light hydrocarbons is absorbed by the tar, which prevents undue thickening; while in warm weather these are given off again and the viscosity of the sealing medium maintained.

Perhaps a word will not be out of place on the seal itself. Almost every engineer who has visited the works and with whom I have discussed the seal has expressed a doubt as to the security of the canvas part of it; and, acting on the belief that this canvas is a real weakness, all kinds of suggestions have been put forward and patents applied for, to cut it out. While I am the last man to assume that any part of any apparatus we use is incapable of improvement, I shall be surprised if the alternative ideas I have so far seen prove superior to the original design.

Only time can settle a question like this, but when we consider the ease with which the canvas receptacle can be renewed, and the complete lack of attention it requires while in use, I should be very reluctant to abandon it until these new and untried substitutes have definitely established their superiority.

SUPERVISION.

The cost of supervision can be anything you like to make it. At Ipswich one man spends two hours per day in general observation and reading the pump runs; if these are normal, his duty ends. Once a week, in addition, a careful internal and external inspection is made, and recorded on a printed form, which is presented to the Works Manager for examination.

This inspection comprises tar levels on the disc, atmospherical observations inside and out, specific gravity of the sealing tar, feeler records of all guiding wheels, and examination of motors and pumps.

The total cost, including current, is 36s. 4d. per week, or £94 12s. 1d. per annum.

ELECTRICITY.

The automatic pumps are all driven by electricity, and we generate with a 6 H.P. Sisson steam engine, coupled to a small dynamo. The average quantity of current required, taken over twelve months, is 44·5 units per week.

The cost of generation is difficult to arrive at, as these tiny engines are amazingly efficient, but the cost is something well under 1d. per unit, which works out at three to four shillings per week.

PAINTING.

The cost of one coat of paint, including galleries, plus labour, is just under £200, so that if we paint once every five years the yearly outlay may be taken as £40.

At Ipswich we have always spent a lot of money annually in examining, painting, and repairing our gasholders; and although these items have not been kept separately, we are satisfied the cost goes a long way to meet similar charges connected with the waterless holder.

"DRI GAS."

The introduction of this holder had a marked effect on the moisture carried forward by the gas in hot weather, and a considerable reduction of water in services and syphons was immediately apparent.

We have 374 syphons in Ipswich; these are kept under observation by a card system, and from these cards I am able to show the result on the chart, Fig. 2.

Another unlooked for advantage became apparent in the reduction of our daily list of bad supplies, and we were able to dispense with three fitters on this work, a state of things that has continued ever since.

I am not arguing that this holder reduces the moisture in the gas, but I do say that, whatever the moisture con-

tent may be in the gas entering the holder, that, and no more, issues from it.

So certain am I of this advantage that I am now seriously considering a " Dri Gas " plant; and if the advantages are proportionate to those already experienced, it will pay for itself in a very short time.

COST.

Pounds, shillings, and pence have to be taken into consideration when new apparatus is under review; therefore, the tenders I received may be of interest.

They numbered eight in all, seven for spiral, and one for waterless, and in each case excluded foundations. The first seven varied from £30,477 to £25,075; the eighth from Messrs. Cockey & Sons, of Frome, for a waterless was £22,500. Here was a saving of at least £2500, which, when added to the reduced cost of foundations, became a very substantial figure.

So manifold are the advantages of this type that were I requiring a holder to-day I should certainly choose a waterless, even if I had to pay a rather higher price for it.

A review of the experiences with this holder would be incomplete without reference to its behaviour during the severe winter of 1928-29.

Eighteen degrees of frost were recorded on several occasions, and the temperature inside the shell dropped to 28° Fahr. Throughout the whole period the holder worked quite smoothly and gave us no anxiety. The only precaution taken was to light the small gas burners provided in the base of the bottom tar tanks, each of which is provided with one flat-flame burner, consuming 6 c.ft. per hour.

APPEARANCE.

Some people in Ipswich pretend that this holder is a shock to their æsthetic senses, while on the other hand an eminent architect emphatically declares that its proportions are correct, its encircling and converging rings a pleasure to gaze on, and that the whole structure is an ornament to the town.

Mr. PRENTICE, in presenting the paper, said: I had a communication this morning from R. & J. Dempster, Ltd., enclosing a drawing of a new canvas seal. Nearly everyone who goes to Ipswich to see the holder asks: " What about the canvas bag? " If you study the drawing, you will see that there is no canvas bag in the sense in which the term is used ordinarily. There is a canvas part of the seal; and because of the fear which exists in the minds of some gas engineers, Messrs. Dempster have produced a seal in which the canvas is retained within very thin sheets of Swedish iron, so that there is no possible chance of that canvas coming away. Whether this is good or bad, I do not know. I am rather interested to know how they get round the corners. So far as my experience has gone there have been no complaints of any mishaps of any kind, and on inquiry I find that this experience is common to all those, in this country at least, who have erected these holders.

DISCUSSION.

The PRESIDENT: The author has been a very hard nut to crack. In fact, I had to use the utmost of my persuasive powers to get him to write this paper. He is the most modest man I know; and he said he felt certain he could not contribute anything of use to the Institution. If I had allowed him to disobey the Presidential command on this occasion, we should have lost a very valuable contribution. [" Hear, hear."]

COST OF FOUNDATIONS.

Mr. J. E. BLUNDELL (Carlisle): I should like to refer to one or two points which influenced me when I had to consider the erection of a gasholder at Carlisle. There was first the question of foundations; and I should like to ask whether it is certain that the cost of foundations would always be less for the waterless than for the spiral-guided holder. I am informed that in the case of a 5-million c.ft. gasholder recently erected, the estimates showed that the cost of the foundations of the waterless holder exceeded those of the spiral-guided holder by £350. To my mind the waterless holder foundations have to support concentrated loads, whereas the loads with the water-sealed holder are well and evenly distributed, which results in cheaper construction, except, of course, in certain special cases. With regard to pressures, Mr. Prentice went to some trouble to remind us that in the top lift we invariably have less pressure than in the lower lifts. I have a gasholder in which the pressure of the top lift is 6 in., which, I think, is sufficient; and while the claim for constant pressure is not sustained, it must be admitted that the variation is negligible. It seems to be of very little value to have constant holder pressure if a station governor cannot be dispensed with altogether. Then comes the question of freezing. It is interesting to note that Mr. Prentice intends to instal a dehydrating plant; and I think he is well advised, because it is reported that the moisture in the gas has been known to freeze on the inside of the waterless holder to such an extent as to tilt the piston and cause it to jamb. I should like to know if the author has had experience of this. Then there is the question of supervision cost; however small it is, one cannot deny that it is an extra cost. The inspection and examination of the tar, and the inspection of the meters and pumps and perhaps other details, seem likely to call for a type of inspection very different from that which has been found sufficient for the water sealed holder.

INFLUENCE OF LOCAL CONDITIONS.

With regard to costs generally, the cost of so large a piece of apparatus as a gasholder is apt to be affected by local factors to an extraordinary degree. From figures submitted to me it would appear that on the average the cost of a waterless holder would exceed that of a spiral holder below the capacity of from three to three-and-a-half million c.ft. Very careful examination of each particular case would have to be made before one could come to a general conclusion. There is a case on record of a 5-million c.ft. tankless holder in one town costing £68,000, whereas in another town, not very far away, a water sealed holder of the same capacity cost only £55,000. I think these are things which perhaps could be explained away. In conclusion, I would say that this is a question which affects the engineer of a small works just as much as the engineer of a large works; and the very simple water sealed holder should not lightly be abandoned in favour of the new idea until engineers have satisfied themselves that they are getting real advantages and are not merely going in for the latest thing.

AN EXAMPLE OF THOROUGHNESS.

Mr. W. W. TOWNSEND (Colchester): I think the inventors of the waterless holder and those responsible for the sale of it are to be congratulated in that the first installation in this country was made by my friend Mr. Prentice, because I happen to know that he has given very great attention to every detail in connection with the installation. I am quite sure that nobody is better fitted to give this innovation the best possible start on its career. Mr. Prentice deals in a few words with several of the details which are of the utmost importance. I have visited the Ipswich holder on several occasions, and I know the extreme care that has been taken to examine the condition of the tar to provide absolutely the right material for the purpose, to check the level of the piston regularly as well as the clearances of the rollers, and to log in detail everything in connection with the holder. Those of us who are not fortunate enough to have waterless holders can learn a lesson from Mr. Prentice's thoroughness. I think it would be desirable that we should all log every detail in connection with our gasholders. It has generally been taken for granted that a holder is an apparatus which will work with practically no attention for long periods, but I venture to say that any attention given to the condition of a holder of any kind is very well justified. Mr. Prentice has told us something of his experience with the actual working of the waterless gasholder for a period of two years; and the very valuable information given in the paper will be of the greatest use to all those who are considering extending gasholder storage capacity. This paper completes the account of the working of the holder, previous instalments of which have been given by Mr. Prentice on other occasions.

NO ROOM FOR DOGMATISM.

On the general question of the type of holder to adopt, I think the waterless holder is now sufficiently well known to be able to take its place among the storage systems which are available to the engineer; but, as Mr. Blundell has indicated, it is not a matter on which to dogmatize. Mr. Prentice is naturally rather an enthusiast with regard to the waterless holder, and has told us a good many of its advantages. I think there is very largely a fashion in these matters. It used to be fashionable to have inclined retorts, and then we went to vertical retorts; and I remember that at a meeting of the Institution about twenty years ago a paper was read entitled " The Scientific Carbonization of Coal." It dealt with a particular system of carbonization, the suggestion being that all other systems were out of date and unscientific. We have learnt only to-day that we are very far from having heard the last word with regard to such an old and well-tried system as the horizontal retort system; and it must not be forgotten, in making these comparisons, that not only has the horizontal retort been improved, but the old type of gasholder has been improved and is continually undergoing modification. Mr. Blundell has indicated one of the improvements. You can increase the pressure which is given by the ordinary floating type of holder; and you not only have this advantage, but you can also, by increasing the thickness of the sheets, make the holder last much longer. I think we have learned a great

deal about the modification of older types of holder during the last few years. I should like to congratulate Mr. Prentice on his paper, and also to congratulate him and his Directors on their courage in being the first in this country to erect this type of holder. I am quite sure that in all the circumstances they were thoroughly justified in the course they adopted. There is a point which has been raised by Mr. Blundell which must not be lost sight of. It is that Mr. Prentice found the waterless holder was the cheaper, and that he was fully justified in recommending it; but this is not always the case, and Mr. Blundell has indicated that there are occasions when the waterless holder will, as tenders show, cost a great deal more than the older types. Every engineer must decide the matter for himself in accordance with his local conditions.

EXTENSIONS WHILE IN USE.

Mr. C. VALON BENNETT (Rochester): In growing districts, or in districts where it is anticipated that gas will be used in very much larger quantities than at present, provision is often made, when constructing a holder of the usual type, for another lift to be added; and I should like to know whether Mr. Prentice, in deciding upon his holder, thought about providing additional storage in the future. Could he tell us whether it is possible to construct a waterless holder so that its capacity may be increased in the future without the necessity for throwing the holder out of action, because I think this is a very important matter? Sometimes the holders are erected with capacities sufficient to meet the next ten or fifteen years' demands, but in a growing district it is necessary to keep the holder in use and, at the same time, be able to enlarge its capacity.

Mr. F. P. TARRATT (Newcastle-on-Tyne): I feel that this matter is of very great importance, and perhaps I might be able to add something from my experience which will help you in considering the provision of further storage. Just recently I had to consider the erection of a 3-million c.ft. holder. When the tenders were received I was very much surprised to find that, with very few exceptions, the holders put forward of the water-sealed type, including a steel tank, were uniformly good, but the prices quoted for the two types of waterless holders were, in my opinion, quite prohibitive. I went into this matter with an open mind; I was desirous, as most of us are, of being more or less in the forefront. We in Newcastle all felt that we should like to adopt more modern methods of storage if possible, but we came to the conclusion, after taking trial borings of the site, that a very considerable amount of work would be involved in the way of piling around the perimeter of the holder, even if we put in a holder of the waterless type. We then decided to pile the site and to have a reinforced concrete slab over the top of the piling, and to put in a water-sealed type. The point that has been made with regard to maintaining even pressure throughout the entire travel of the holder does not appeal to me. I feel that in erecting holders we need not hesitate to make inner lifts sufficiently heavy to give us an adequate pressure. Holders built during the past 20 years, or probably for a longer period, have been in a great many instances skimped with regard to the top lift, and if you can provide, as Mr. Blundell appears to have done, and as I have, an inner lift pressure of 6½ in.—and most of us at times of peak load are compelled to use a booster to supply the heavy demand—it is very seldom indeed that you are confronted with any difficulties in that respect. On two occasions I have visited Germany and have seen the holders there. I am extremely pleased with them, and no one was more disappointed than I that I had not an opportunity of putting in a waterless holder; but I could not recommend my Directors to spend a considerable amount more capital, which would never earn anything, in the provision of a structure which to an extent would be an added responsibility, because the holders we have used in the past have certainly not given us very much anxiety. Finally, I should like to thank Mr. Prentice for his paper.

TROUBLE DUE TO HEAT.

Mr. C. H. CARDER (Rio de Janeiro): Since we have time available, you might perhaps be interested in hearing of some of the difficulties that arise in operating a waterless gasholder under conditions diametrically opposite to those dealt with by Mr. Prentice. The trouble in this country, in Germany, and the United States, in which latter country I have inspected many of these holders, is due to frost, and the condensation of water both in the seals and on the walls of the holder, where the formation of ice has tended to prevent the movement of the piston. On the other hand, we have had a waterless holder in Brazil, but the difficulty there has been the partial carbonization of the sealing medium on the walls of the holder as the result of a sun temperature of from 120° to 170° Fahr. We had the pleasure of receiving Mr. G. M. Gill when he visited us a little more than a year ago, and I think he will endorse the statement that temperature conditions in Brazil can be trying, and that the problems there, not only in regard to holder operation, but in various other directions, are very different from those encountered in this country. We overcame the difficulty of pitching from the sealing medium by the use of a partial mixture of water gas tar with the dehydrated coal tar, and thus forming a sealing medium with a characteristic curve of viscosity totally different from that recommended and usually adopted, but which we have found by experience remains uniform throughout our summer and our winter—which may be described as six months' hot weather and six months' summer. [Laughter.] We find that the supervision required for a waterless holder is not in effect materially greater than that which we consider ought to be exercised with the ordinary type of holder. I agree thoroughly with the conclusion that on the whole we do not give our gasholders that attention which they as mechanical units ought to receive. In Rio we have consistently adopted the policy of maintaining our gasholders as though they were machines and not as though they were structures, and I think you will find that it pays to do that.

Reference has been made by Mr. Prentice to the use of internal lifts in the holders in overcoming the difficulty of climbing the crazy ladder which exists inside the holder down on to the piston. In the early stages we found that that difficulty was so real—with a temperature inside the holder of round about 100°, 110°, or 115°, and in view of the inevitable emanations from the sealing liquid, which made the atmosphere extremely disagreeable—that the inspections were not properly carried out, and after trying to do the job myself I sympathized with the objections of the men whose job it was to do it regularly. Therefore, we have installed an electric lift inside the holder, but there are one or two rather unusual features in connection with it. First, it is obviously undesirable that there should be switches of any kind inside a gasholder, where there is a possibility, however remote, of an explosive atmosphere. The machinery room is in a steel cabin built outside the roof at the periphery of the holder; all the switch gear is there, and it is distantly controlled by ropes. We have also installed limit switches governing the maximum movement of the cage, which is automatically controlled and varied by the distance of the piston itself. It may be that light is not necessary in the holders in this country, but in Rio we have 12 hours of daylight each day throughout the year, roughly speaking, and we find it is a distinct advantage to have light inside the holder to facilitate examination. Again, we have eliminated any possibility of explosion by using the ship bulk-head type of lighting, internally and externally, with 12-in. bull's-eyes let into the roof on six radials. We have a flood light type of searchlight constructed above that in a water-tight cage.

The PRESIDENT: I disagree entirely, as I am sure the majority of us here will disagree, with the remarks of Mr. Carder in which he gave the impression that there is a shocking neglect of the maintenance of gasholders in this country. I do not know how long Mr. Carder has been away from this country, or what experience he has in this connection, but I am no different from the majority of gas engineers, and I can show bills indicating that I have expended £45,000 during the last ten years on my gasholders in Leeds. This represents an expenditure of £4500 a year, or a halfpenny on the price of gas. There may be isolated cases in which gasholders have been neglected, but I should not like it to be assumed that gas engineers generally are neglecting their gasholders, because we are not.

WIND PRESSURE.

Mr. F. H. ROBINSON (Harrogate): The reference which has been made to the advisability of providing facilities for increasing the capacity of a holder subsequent to its erection draws attention to the problem of resisting wind pressure. It seems to me that the problem of wind pressure becomes more serious with the waterless type of holder than with the ordinary type. To begin with, the height of the particular holder referred to in the paper is roughly twice the diameter, and that is a very serious consideration from the point of view of wind pressure; if the capacity of a holder is to be increased in the future so that the ratio of height to diameter is (say) 2½ : 1 or 3 : 1, the problem of wind pressure becomes very serious. In the ordinary type of holder the floating portion has a comparatively smooth surface, but in the waterless type there are numerous flanges, all of which offer resistance to the wind. If you increase the height you have to consider the foundations. Are you going to get serious tension on the concrete in the foundations on the windward side of the holder? If so, reinforcement will be required, and any information that Mr. Prentice could give as to how this problem is dealt with would be instructive. Wind pressure is a very peculiar thing, and it is a more serious matter in the case of the waterless type than in the ordinary type of holder.

With regard to the problem of expansion, it seems to me that the outer shell will expand at a greater rate than the piston. Is there any greater trouble in the summer time, due to leakage, or is there any more difficulty in maintaining a tight seal in the summer time than in the winter?

MR. PRENTICE'S REPLY.

Mr. PRENTICE, replying to the discussion, said: Mr. Blundell has asked whether the cost of foundations of the waterless

holder would always be less than the foundations of the usual tank type of holder. If you are starting *de novo,* I should say the cost would always be less. The holder I have weighs 800 tons, but the weight of the tank holder of similar capacity, including water, is 18,000 tons. I cannot conceive any conditions in which the foundations would cost less for the latter than for the former. I am amazed to hear Mr. Blundell say that the variation in pressure in an ordinary holder is negligible. He is the first engineer I have ever heard say that, though I have heard hundreds of them say the reverse. He may be fortunate in having very large mains. If we could take up all our mains from narrow streets and replace (say) the 12-in. mains with 24-in. mains, he might be right, but we all know that in view of the congested state of our towns it is practically impossible for us to enlarge our mains. We have therefore to be content with increasing pressure. When the pressure is increased to an extent to enable us to give a satisfactory supply at the extremes of the district, the uncoupling of a holder 2 or 3 or 4 in. is a very serious matter; at least it is in Ipswich. I am very glad Mr. Blundell has not found any difficulty in that direction, and he has been saved a great deal of trouble in consequence. As to internal freezing, you will remember that the winter before last was fairly cold, there being about 18° or 20° of frost at Ipswich, but the lowest temperature recorded inside the holder at that time was 26° Fahr. There was ice about, certainly on the seal, and the little particles or globules of water, some as big as a penny piece, did freeze and remain there, but a man was sent round with a bucket and picked them off. I examined the sides of the holder very carefully during the frost. It is perfectly true that the sealing medium on the holder had a rather black snowy appearance—*i.e.,* not smooth and shiny, but at the same time it was as slippery as it could possibly be, and not the slightest difficulty was experienced during that cold weather, and I do not think we are likely to have colder weather than that.

With regard to the type of inspection which it was suggested by Mr. Blundell is necessary for the waterless holder as compared with the spirally-guided type of holder, the President has told us of the great care with which our holders are maintained. He has spent thousands of pounds on the maintenance of his holders, and he has been exceedingly wise in doing so. I have not separated out the cost of the maintenance of my holders, although I have spent a great deal of money on them, but I am perfectly satisfied that the higher maintenance costs of the ordinary type of holder go a long way to offset the additional capital cost that may be incurred by adopting the waterless holder. At the same time, the more attention that is given to anything, the longer it will last and the more satisfaction it will give.

Cost of Foundations.

As to the cost of foundations practically all the holder builders, when they quote, leave the undertaking to provide the foundations. In Ipswich the foundations cost about £1500 for the waterless holder, whereas the foundations for an ordinary holder of similar capacity would certainly be from £4000 to £5000.

The point was raised by Mr. Bennett as to whether facilities could be provided to add to the capacity of the waterless holder while it is in use. That has been done on several occasions. With regard to wind pressure, it is true that if you heighten the holder you increase the effect of wind pressure. At Ipswich, however, we have experienced a gale of from 85 to 90 miles per hour on that holder, but we were not able to detect the slightest variation or oscillation at all. On the other hand, I have looked at a retort house chimney and seen it oscillate as much as 7 in. Careful calculations will reveal the astonishing fact that even if there were no holding-down bolts to the holder, it would not blow over because the pressure of the wind is not sufficient. When you consider, however, that there are between 20 and 40 bolts 2 ft. 6 in. long in the foundations, I do not think you need have the slightest hesitation in heightening the holder. Mr. Tarratt suggests that the lift is immaterial because he has boosters. Before I put in the new holder I had actually prepared drawings for a booster set because I could not carry on without increasing the pressure, but I was reluctant to instal it because it means attention, and labour is one of the great factors in costs; anything we instal must be considered very carefully from that point of view. If I could get the pressure I want without the booster, and therefore without the cost of running it and attending to it, I could gain a point. That was one of the reasons which induced me to go in for this waterless holder.

The experiences of Mr. Carder are interesting. He seems to suggest that the thickening of the sealing medium is a very serious difficulty, but apparently the difficulty was got over easily by him, and therefore I do not think his remarks in that respect constitute a very serious adverse criticism of this type of holder. Mr. Carder also pleaded for constant supervision, and I think I can assure him that as a rule in this country we do look after our holders. That is why some of us at least hold the view that the cost of supervision is well worth incurring—whether on a waterless holder or anything else. As to expansion, there is a slight expansion in the shell of the gasholder, but it is very small, and is more than compensated for by the elasticity of the seal. I have never discovered—and I do not think anybody else has ever discovered—in one of these holders the slightest difference between the gas underneath the disc and the air above it.

Too Much Criticism of the Waterless Holder.

Mr. J. L. Chaloner (Waterless Gasholder Company): I think it is rather wrong, in considering a new system, to make too direct a comparison with the hitherto conventional system; if you study a new innovation you should compare it relatively to modern evolution in the particular industry in general. The point I wish to make is that during the last few years we have heard too much, as a criticism of the waterless holder, about it being a machine. We engineers live in a very hectic atmosphere to-day; we are machinists dealing with machines, and I do not think it is at all a criticism to describe a waterless holder as a machine for the very reason that if we design it as a machine then, *ipso facto,* we deal with it as a mechanism, requiring supervision. At the same time, the supervision is not so serious a factor as had been made out; those gentlemen who criticize it from that point of view lack actual experience, and, therefore, when we hear Mr. Prentice talk about the relatively small cost of supervision we can accept it as a fact and as being a general advantage of the waterless holder. One is apt to become dogmatic immediately one deals with an innovation. For instance, consider the foundations. A speaker has asked whether the foundations of a waterless holder are always cheaper than those of any other type of similar capacity. During the last five or six, or perhaps eight, years something like thirty holders have been installed in the Ruhr district of Germany. Inasmuch as that is a colliery district the subsidence of the ground is an important factor. The problem there was not one of expense but merely one of securing reliability in operation, so that you cannot always say that the foundations will be cheaper, without taking into account the exact local conditions prevailing. Mr. Prentice has shown a material saving merely because he has peculiar conditions to cope with, whereas another gentleman has pointed out that in respect of a 5-million c.ft. holder he had to pay £3000 more for the foundations of a waterless type of holder than for the foundations of an ordinary one. That may be so; but I wish to emphasize that it is no use basing general statements upon the conditions in one particular place. With regard to the problem of supervision, my experience is that out of sixty holders in Germany only one is fitted with an external lift. I have inspected the holder about a dozen times, but I do not think the lift was working on more than two occasions. I asked the engineer in charge of a 12½-million holder why he did not get a lift, and he gave me what appeared to be a rather extraordinary reply. He said that if he fitted a lift to the holder the man in charge would merely go up in the lift, look inside the hatchway and come down again, but if he has to walk he pauses at every gallery and looks closely at the holder each time, and he is asked to inspect the holder both when going up and when coming down.

I should like to express my appreciation to Mr. Prentice who has been such an enthusiast in connection with the holder at Ipswich.

Col. W. M. Carr (Stretford): I am seeking enlightenment, and this problem of supervision interests me most in regard to the waterless gasholder. It seems to me that in considering relative costs we have to remember that the waterless holder has mechanical pumps to pump the tar, and that a daily inspection is necessary, whereas a weekly inspection is adequate for an ordinary holder, in my opinion, and the difference in the costs of the two types in that respect must be capitalized. Mr. Prentice's figure of £94 12s. 1d. per annum is a very low figure. In respect of a holder of smaller capacity than the Ipswich holder—(say) as small as 50,000 c.ft. (I believe that one with a capacity even as low as 35,000 c.ft. has been built)—that supervision charge is a very serious matter, and bears a high incidence in relation to the cost of the holder. I should like to know whether the figure of £94 12s. 1d. includes all charges—even the cost of recording all the logs it is necessary to keep respecting the working of the holder.

The President: I disagree with the suggestion that a weekly inspection is sufficient for an ordinary holder. I insist on a daily inspection of all seals, and ensure that they are overflowing, and I think that practice is fairly general.

The meeting then adjourned for luncheon.

Benzole Recovery

with particular reference to Gas-Works Practice.

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INTRODUCTION.

At the present time the annual production of benzole in this country is about 30 million gallons, while the total quantity of motor spirit consumed amounts to some 900 million gallons. The annual production of motor benzole, therefore, only amounts to about 3 per cent. of the total production of motor spirit, and there is ample scope for a considerable increase in the quantity of benzole produced without affecting the motor spirit market. The motor benzole manufactured in this country at present is obtained almost entirely from coke-oven gas. Even if the benzole was recovered from all the coal carbonized at gas-works, as well as at coke-oven works, the annual production would only amount to some 6 or 7 per cent. of the total motor spirit requirements.

Although the removal of benzole at gas-works was practised on a considerable scale during the war, apparently less than a dozen gas-works are recovering to-day. The rapid decrease after the war in the number of works recovering benzole appears to have been due chiefly to financial considerations, but also to certain troubles associated with benzole recovery during the war period. As pointed out by F. Nicholls[1], however, no definite evidence has been published on the financial side, and the troubles experienced during the war have been largely overcome by post-war legislation and by developments in gas manufacturing and benzole recovery methods, so that the time appears to be ripe for a re-survey of the position. If benzole can be recovered from town gas without financial loss, then every endeavour should be made to encourage gas-works to undertake the recovery of this valuable motor fuel, since by so doing they assist in utilizing our coal resources to the best advantage, and money now spent abroad in purchasing motor fuel will be kept in this country. It was presumably with these objects in view that home produced benzole was not included when the recent tax of 4d. per gallon was placed upon motor fuel.

Benzole possesses certain well-recognized advantages over the petrol hydrocarbons, the chief being its ability to withstand a much higher compression ratio in the cylinder of an engine without detonation ("knocking"). Since the present trend of motor engine design is to increase the compression ratio in order to achieve high efficiency and greater power, this advantage is becoming of increasing importance. Although other methods of increasing the anti-knock properties of motor fuels are being explored, such as the addition of anti-detonants—*e.g.*, lead tetraethyl and iron carbonyl—and blending with cracked petrols, particularly those produced by vapour phase processes, these methods suffer from certain disadvantages. The quantities of lead tetraethyl or iron carbonyl which it is possible to add to a given fuel are limited, owing to deposition of lead or iron on the sparking plugs and in other parts of the engine, and cracked petrols are unstable on storage and rapidly lose their anti-knock properties. Benzole, on the other hand, is a highly satisfactory anti-knock fuel *per se*, and is subject to neither of these disadvantages.

GENERAL CONSIDERATIONS.

As average figures for this country it may be assumed that when coal is carbonized either on coke ovens or at gas-works, about 0·1 gallon of motor benzole per ton of coal carbonized is contained in the tar produced, while 2 gallons per ton of coal are contained in the gas.* The benzole contained in the tar is recovered during the usual process of tar distillation. Since unpurified coke-oven gas is partly used on the plant for heating the ovens, and the surplus is sold either to local gas undertakings or for industrial purposes at a relatively low price, or burnt off as a waste product, the value of the benzole as gas is low and its recovery is economic and has become standard practice. Purified town gas, on the other hand, is sold at a much higher price than coke oven gas, and the benzole in the gaseous form is therefore relatively more valuable. The question of whether it is profitable to recover the benzole from town gas depends primarily on the price obtainable for the recovered product, the value of the benzole as gas, and the cost of recovery and any refining which may be carried out on the works.

Before discussing, however, the economics of benzole recovery from town gas, the effect of the removal of benzole on the calorific value of the gas must be considered. Benzole vapour has seven to eight times the calorific value of coal gas. Consequently, when the benzole is removed, besides a loss in volume there is a reduction in the calorific value of the gas. The complete removal of the benzole from a straight coal gas involves a decrease in calorific value of about 5 per cent. and a loss in volume of rather less than 1 per cent., the exact figures depending upon both the quantity and the quality of the recoverable benzole, and upon the calorific value of the gas. Decrease in calorific value necessitates a greater volume of gas being delivered to consumers in order to supply them with the same number of therms. If a straight gas only is made, and the benzole is removed, an additional volume of gas must be produced both to make up for the loss in volume caused by removal of the benzole vapour, and also to supply to consumers the extra volume of gas necessitated by the decrease in the calorific value. In Table I., the decrease in calorific value of the gas, the consequent increase in the volume of the gas to be supplied to consumers, and the increase in the total gas make are given as percentages of the original values without benzole recovery for varying quantities of benzole removed from the gas. In calculating the data in this table, it has been assumed that the benzole removed from the gas has a calorific value of 1·50 therms per gallon.

TABLE I.

Calorific value of gas . . . (C) = 550 B.Th.U. per c.ft.
,, ,, ,, benzole . . (B) = 150,000 B.Th.U. per gallon
Volume occupied by 1 gallon of benzole as vapour . . . . (v) = 39 c.ft.

Gallons of Benzole Removed per 10,000 C.Ft.	Per Cent. Reduction in Calorific.	Per Cent. Extra Volume of Gas to Consumer.	Per Cent. Extra Volume of Gas to Make.
(*n*)			
1	2·35	2·40	2·62
2	4·71	4·94	5·77
3	7·09	7·64	8·90

For a gas of lower calorific value, the percentage reduction in calorific value and the percentage increase in the quantities of gas, will be correspondingly greater. The following formulæ enable the figures to be calculated for other values of (C), (B), and (*v*) :

$$\text{Per cent. reduction in calorific value} = \frac{100n\,(B - Cv)}{C\,(10{,}000 - nV)}$$

$$\text{Per cent. extra gas to consumer} = \frac{100n\,(B - Cv)}{10{,}000\,C - nB}$$

$$\text{Per cent. extra gas to make} = \frac{100\,nB}{10{,}000\,C - nB}$$

Although most systems of carbonization at gas-works produce a gas with a gross calorific value of about 550 B.Th.U. per c.ft., chiefly in order to give greater flexibility of working, it is usual to declare a gas of lower calorific value, which is obtained by mixing the straight gas with producer gas, blue or carburetted water gas, or other diluents. It is assumed, therefore, in the discussion

* Yorkshire coals, in particular, as well as Durham coals give higher figures, and Welsh coals give lower.

of the economics of benzole recovery which follows, that when the benzole is recovered, the decrease in the calorific value of the straight gas, caused by the removal of benzole, is compensated for by a decrease in the proportion, which it is necessary to add, of the gas of lower calorific value. In this case, if the calorific value of the diluent gas is unaltered, it is necessary to make an additional volume of straight gas to compensate for both the benzole recovered, as indicated above, and for the smaller quantity of the diluent gas used. Alternatively it is possible to increase the calorific value of the diluent gas—*e.g.*, by carburetting—when the benzole is recovered.

If the declared calorific value of the gas must be maintained high for purposes of distribution, and approximately the same as that of the straight gas (550 B.Th.U. or over), benzole recovery will not be possible.

THE ECONOMICS OF BENZOLE RECOVERY AT GAS-WORKS.

Owing to the diversity of methods of gas production and variations in prices at different works, it is impossible, in a paper of this character, to deal in detail with the actual costs of benzole recovery. It is therefore proposed merely to discuss the general factors which govern benzole recovery on gas-works, showing that a substantial profit may reasonably be expected on many works.

The selling price of refined motor benzole is fixed by the market price. This price is for a product consisting essentially of the aromatic hydrocarbons—*i.e.*, with a paraffin content of not more than 5 to 6 per cent. by volume. Benzole produced by some systems of carbonization used at gas-works—*e.g.*, vertical retorts—may contain 20 per cent. or more of paraffins, in which case the selling price should be correspondingly reduced, owing to the lower market value of the paraffins. Moreover, although the presence of paraffins may be regarded as unobjectionable if the benzole is to be used as motor fuel, a high and varying paraffin content complicates and increases the cost of blending the benzole with petrol in order to produce that standard high-quality motor fuel which is desirable from the sales point of view.

The costs of recovery—*i.e.*, those expenses which are especially incurred in running the benzole recovery plant, including labour and all overhead charges—will depend upon the quantity of benzole which is present in the gas, the proportion which it is desired to recover, and upon the method of recovery used. When the benzole plant also operates as a naphthalene washer, a portion of the total cost should be debited to naphthalene removal, and the advantage of reducing the sulphur impurities in the gas by benzole recovery also deserves consideration. In order to obtain the maximum efficiency of recovery from the gas and keep the recovery costs as low as possible, the benzole should be recovered from the straight coal gas before admixture with producer gas, blue water gas, or other diluents. If carburetted water gas is made, then the desirability or otherwise of mixing it with the straight gas before benzole recovery will depend both on quantity and quality of the benzole contained in the carburetted water gas. The former will vary with the amount of carburetting carried out.

It is usually more profitable to refine the recovered benzole on the works than to sell it as crude. The cost of refining will depend chiefly upon the quality of the recovered product, particularly upon the quantity of unsaturateds which it is necessary to remove. Both the quantity and the quality of the crude benzole recoverable from any gas can be determined. It should be possible, therefore, on any gas-works to arrive at the probable costs of recovery and refining with a fair degree of accuracy. These costs of recovery and refining are then expressed as costs per gallon of refined motor benzole produced.

To determine the value of the benzole as therms in the gas, however, is difficult, owing to the fact that the economics of benzole recovery are intimately bound up with those of gas production. To assess these therms at the price of the gas to the average consumer is obviously unfair, because the assumption is made that, if the benzole is not recovered, the equivalent therms can be sold immediately as gas. The output of gaseous therms is fixed by the normal demand, and complete benzole recovery increases the total output by about 5 per cent. The benzole plant, which may be regarded as a customer who takes about 5 per cent. of the total thermal output without incurring distribution, service, or maintenance charges cannot in fairness be debited on the highest scale of charges. With more justification perhaps, the benzole therms in the gas are often charged to the recovery plant at the cost of gas into the holder. Objection may be raised even to this basis of charge, since it implies that the recovery of benzole is most profitable when the cost of gas into the holder is lowest, and would mean that it should be most favourable to recover benzole when the gas-making plant is working at its maximum capacity. These conditions are unfavourable to benzole recovery owing to the increase in gas make which would be required. Moreover, in order to reduce the burden of overhead charges the extra thermal output entailed by benzole recovery is most desirable when the normal demand for gas is lowest—*i.e.*, when the cost into the holder is highest. These objections would be removed if the cost into the holder were exclusive of capital charges. These considerations have been adequately discussed by F. Firth in a recent paper on the economics of benzole recovery at gas-work.[2]

Since the selling price of the benzole is fixed and the cost of recovery and refining can be determined fairly accurately, it is possible, however, without going into the detailed costs of gas production, which vary at different works, to compare the net price received for the recovered benzole with the price at which the benzole is actually sold as therms in the gas. The calorific value (gross) of a gallon of benzole consisting almost entirely of the aromatic hydrocarbons is 1·5 therms (approx.); hence the net price per therm can be calculated. Actually, in order to obtain these therms as liquid, a greater quantity of therms must be removed from the gas according to the quantity of unsaturateds, &c., that are destroyed in the refining process. In Fig. I. the net value of the benzole per therm has been plotted against the cost of recovery and refining for varying refining losses.

According to published figures,[2] the total cost of recovery and refining, including labour and all overhead charges, for a medium sized gas-works recovering benzole from horizontal retort gas is about 6d. per gallon of refined benzole. At to-day's selling price of 1s. 5d. per gallon for refined benzole, the net price per gallon is about 11d., which, with 5 to 10 per cent. refining losses, is equivalent to a value of 6d.-7d. per therm in the gas. Some indication of whether it is profitable to recover benzole at a works of this character is afforded, therefore, by a consideration of whether it is profitable to provide an outlet for an additional 5 per cent. of the therms sold, at a price of 6d. to 7d. per therm, without incurring additional distribution charges. The " new customer " taking these additional therms does not require a guaranteed supply, since the benzole recovery plant can be closed down if necessary when there is a sudden extra demand for gas. Actually many medium and large sized gas-works already quote prices to their largest consumers well below this figure, some favourably situated undertakings quoting figures as low as 4d. per therm, even for gas containing relatively little water gas and no coke oven gas. There is little doubt that these and other undertakings would be prepared to quote even lower figures for sales of the size and character indicated.

It is obvious from the considerations discussed above that the recovery of benzole from gas produced in vertical retorts is less attractive than from that produced in horizontals, but, although benzole recovered from vertical retorts without steaming may contain about 10 per cent by volume of paraffins and 10 to 15 per cent. by volume of unsaturateds, the difference in the value of therms as benzole and the price at which therms are sold to large consumers by many gas-works using verticals is still sufficiently wide to indicate that benzole recovery would be profitable on these works. Even if the retorts are steamed and give a benzole with 20 per cent. of paraffins and 25 per cent. refining loss the net value of the benzole as therms in the gas apparently is still not less than 4d. per therm.

So far we have assumed that no alteration has been made in the declared calorific value of the gas, the decrease in calorific value of the straight gas caused by benzole recovery being compensated for by a decrease in the proportion of the diluent gas. F. Firth[2] has published a hypothetical cost sheet, which shows that it is actually cheaper to adjust the calorific value of the gas by removing the

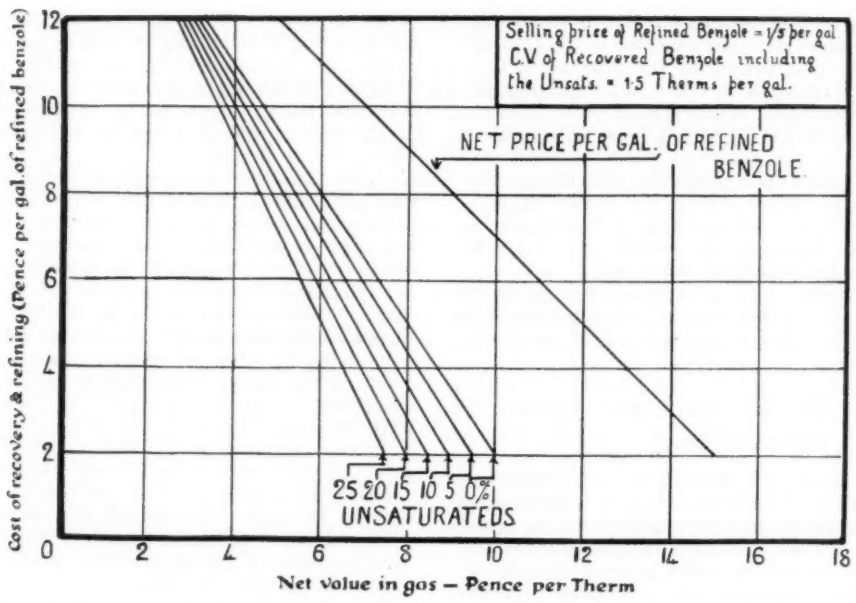

FIG. 1.

benzole than by dilution with air, producer gas, or blue water gas. The advantages of benzole recovery for adjustment of calorific value do not appear to have been fully appreciated by gas engineers. When the straight gas, without benzole recovery, is mixed with the diluent gas, this gas may be regarded as being carburetted with benzole, which is an expensive material compared with gas oil. If carburetted water gas is already being made, and the cost of replacing the benzole therms by extra carburetting is considered, Hollings, Pexton, and Chaplin[2] have pointed out that this cost depends not only on the cost of the gas oil, but also on the efficiency of the carburetting process. This efficiency varies with the amount of carburetting necessary, decreasing with increase in the quantity of gas oil used.

If instead of increasing the ratio of coal gas to water gas, &c., it is found desirable to reduce the declared calorific value of the gas, then a debit to the benzole recovery plant of the extra costs of storage and of distribution of the lower grade gas must be admitted. The extra cost of distribution involved, however, apart from any initial cost of readjustment of gas appliances, is the cost of driving the extra gas through the pipe lines to the consumer, and, therefore, should be exclusive of other charges which make up the difference between the cost of gas into the holder and the price to the consumer. When determining this extra cost, the reduction in the specific gravity of the gas caused by removal of benzole should be taken into consideration. Calculation shows that, if allowance is made for the reduction in specific gravity, the cost of delivering this extra gas to the consumers is only about half the additional cost which would be necessary if no reduction in specific gravity occurred.

Finally, it is pointed out that most gas undertakings provide sufficient plant to meet the high demands which are made during the winter months. At all other times of the year a portion of the plant is standing idle. The recovery of benzole which can be discontinued when there is a sudden demand for gas provides an additional outlet for therms and thereby reduces the financial burden of carrying idle plant. The cost of gas production with and without benzole recovery, therefore, should be made on the basis of normal demand and not of maximum potential output.

THE RECOVERY AND REFINING OF BENZOLE AT GAS-WORKS.

Since the economic extraction of benzole from coal gas depends largely on the cost of recovery and refining, any modifications or improvements in these processes, which reduce their cost, will make the extraction of benzole from town gas more attractive. In this paper, it is only possible, in dealing with these processes, to consider certain aspects which concern gas-works practice, and to refer more particularly to recent developments.

RECOVERY BY ABSORPTION: OIL WASHING PROCESSES.

During the war period, when benzole recovery was carried out extensively on gas-works, troubles were experienced owing to the deposition of naphthalene in the mains, and in some quarters the impression still appears to exist that benzole recovery is necessarily associated with such troubles. The difficulties caused by naphthalene deposition during the war undoubtedly were due to the fact that the benzole recovery plants were operated in the wrong way for naphthalene removal, and the wash-oils used were of poor quality or the wrong type. Actually the simultaneous recovery of benzole and the removal of naphthalene from the gas should present little difficulty; in fact, the two operations can be conveniently combined in a single washer. Although benzole recovery at the present time is carried out only on a few works, the desirability of naphthalene removal has been realized and is becoming standard practice.

Gas oil is usually employed at gas-works for naphthalene removal, owing to its low price, its freedom from this hydrocarbon, and to the fact that it is a satisfactory oil for carburetting water gas. Removal of naphthalene from the gas is effected by scrubbing the gas with about 20 gallons of oil per million c.ft. of gas. The spent oil after naphthalene removal is used for carburetting purposes. If the carburetted water gas made is 20 per cent. of the total gas make, the quantity of oil required for carburetting would be about ten times the amount required for naphthalene removal. This oil, therefore, is already available on many gas-works for benzole recovery. Although trouble with this oil owing to sludging has been experienced under certain conditions in coke oven recovery practice, [4], [5] no difficulties of this nature apparently occur under gas-works conditions, owing to the freedom of the gas entering the benzole scrubbers from hydrogen sulphide and tar fog, and to the lower scrubbing temperatures used. Moreover, the quantity of gas oil used for carburetting usually is such that the oil in circulation for benzole recovery need only be used a comparatively short time. Even if carburetted water gas is not being made, gas oil is still one of the best oils to use for benzole recovery on gas-works, but if desired creosote or other oils may be employed instead.

A comprehensive survey of the absorptive capacities of oils which have been used or proposed for benzole recovery has been carried out on behalf of the Joint Research Committee of the National Benzole Association and the University of Leeds, the results of which are summarized in

TABLE II.—*Absorptive Efficiencies of Wash Oils for Benzole Recovery.*

Wash Oil (Fresh).	Distillation Range.	Sp. Gr. at 20° C.	Viscosity at 20° C. R.S.	Gm. per 100 Gm. Solution.	Vols. per 100 Vols. of Absorbent.
1. Naphthalene (in solution)	B.P. 218	..	..	5·5	..
2. Tetralin	205–207	0·976	30·7	5·25	6·15
3. Tetralin (commercial)	206–225	0·975	30·6	4·9	5·7
4. Tetralin (3)—10 per cent. by weight of naphthalene	206–225	0.9825	30·9	4·95	5·85
5. Light creosote fraction (free from tar acids)	205–265	0·9535	30·5	4·55	5·15
6. Chlorinated light creosote fraction	200–95 per cent. at 288	0·976	31	4·3	5·0
7. Sulphur treated creosote (B.P. 239, 264) (refractioned)	220–95 per cent. at 320	0·9875	36·5	4·1	4·8
8. Light creosote (tar acids 17·5 per cent. by vol.)	200–95 per cent. at 300	1·0135	34·6	3·95	4·75
9. Medium creosote	200–95 per cent. at 350	1·0310	37·6	3·6	4·35
10. Blast furnace creosote	210–95 per cent. at 340	0·935	40·0	3·65	4·05
11. Green oil	250–90 per cent. at 385	1·088	70	2·95	3·75
12. Cresol (mixed isomers)	197–200	1·039	65	2·8	3·4
13. Shale oil	226–95 per cent. at 390	0·838	38	3·05	3·0
14. Gas oils (1)	210–95 per cent. at 400	0·8635	40·0	2·9	2·95
14. Gas oils (2)	260–95 per cent. at 365	0·849	44·5	2·8	2·8
15. Light gas oil distillate	215–95 per cent. at 285	0·8295	32·5	3·2	3·1
16. Gas oil (14 (1)) 12 per cent. by weight of naphthalene	210–95 per cent. at 400	0·8805	37·0	3·3	3·4
17. Low-temperature tar (1) containing phenols	200–95 per cent. at 345	0·981	52·5	3·35	3·87
18. Low-temperature tar (1) free from phenols	220–95 per cent. at 357	0·962	41·5	3·75	4·27
19. Low-temperature tar (2) containing phenols	206–95 per cent. at 320	0·984	51·5	3·55	4·12
20. Low-temperature tar (2) free from phenols	200–95 per cent. at 320	0·935	34·5	3·95	4·37
21. Bergius product containing phenols	200–95 per cent. at 340	0·986	44·0	3·75	4·37
22. Bergius product free from phenols	200–95 per cent. at 305	0·946	32	4·2	4·7

Table II. It will be seen that fresh gas oil has an appreciably lower absorptive capacity than fresh creosote oils. Under working conditions, however, it has been found that the absorptive capacities of these two types of oil become more nearly the same owing to the fact that the absorptive capacity of gas oil increases slightly on use, due to absorption of naphthalene and other benzenoid constituents from the gas, while the absorptive capacity of creosote tends to decrease through removal of the lower boiling constituents and thickening.[4]

Benzole recovery as well as naphthalene removal can be carried out in a single washer, or two separate washers may be employed. If a single washer is used, the naphthalene and benzole taken up from the gas by the oil in the washer are both removed from the oil in the debenzolizing still. The crude benzole thus obtained contains practically all the naphthalene which was in the gas. On redistillation ("once running") the naphthalene is left in the still residues, from which the greater portion can be separated on cooling before returning them to the wash-oil in circulation. Instead of driving the naphthalene over into the crude benzole from the debenzolizing still, the reflux in the column on this still can be tapped off separately.[6] Although these wash-oil residues are still saturated with naphthalene at atmospheric temperatures, they represent such a small proportion of the total oil in circulation that the actual naphthalene content of the oil passing through the washer can be kept down to a very low figure, thus ensuring a considerable reduction in the naphthalene content of the gas. If desired, the removal of naphthalene and benzole from the benzolized oil, and the once-running operation, can be combined by the use of a Sylvester or Holmes column on the stripping still, which enables a benzole approximating to a once-run benzole to be obtained continuously direct from the stripping still. The naphthalene is separated from the wash-oil reflux from these columns on cooling, before returning this oil into circulation in the recovery plant. The method of combined naphthalene and benzole removal can be used with gas oil, or other wash-oils, providing they are free from naphthalene before circulating the oil to the gas scrubbers.

If complete freedom of the gas from naphthalene is desired, this is best effected by the use of separate washers for benzole recovery and naphthalene removal, in which case, if the naphthalene washer is placed after the benzole washer, advantage may be taken of the increase in the absorptive capacity and reduction in viscosity of the wash-oil in the benzole scrubbers caused by the presence of naphthalene in solution in the oil.[7] The oil passed through the naphthalene washer should be entirely free from naphthalene. If gas oil is used for carburetting, this presents no difficulty. There also appears to be no objection to passing the oil from the naphthalene scrubber to the benzole recovery plant, to make up for the usual losses of oil in this plant, providing the same type of oil is used for both naphthalene removal and benzole recovery.

RECOVERY BY ADSORBENTS: THE ACTIVE CARBON PROCESS.

Briefly this method consists in passing the gas through a layer of active carbon, which retains the whole of the easily condensable constituents present in the gas. When the carbon becomes saturated with these constituents, they are recovered by heating the carbon by means of steam. The benzole and water resulting from the condensation of the hydrocarbon vapours and steam are separated in the usual way.

Until recently, the active carbon in plants erected for the recovery of benzole from town gas by this process had only a comparatively short "working life," owing to accumulation of non-volatile substances in the pores of the carbon. Even when the gas has been prefiltered through active carbon to remove naphthalene and other high-boiling constituents in the gas, the active carbon showed a decrease in adsorptive capacity of over 50 per cent. after about 100 saturations and steamings. Owing to the high price of the adsorbent material, this rapid rate of deterioration precluded the economic success of the process.

During the last few years a comprehensive investigation both in the laboratory and on the technical scale has been made by the research staff of the Gas Light and Coke Company on the causes of this deterioration of the carbon. This investigation, the results of which have been published in a paper by Hollings, Pexton, and Chaplin,[3] has led to considerable improvements in the process. It was found that the fouling of the carbon took place chiefly during the heating of the carbon to remove the adsorbed benzole. The rate of deterioration was also found to be dependent on the relative directions of the gas and steam flow through the bed of carbon, the best results being obtained when these were passed in opposite directions—the gas upwards, and the steam downwards—thus rendering it more difficult for impurities of high molecular weight to penetrate far into the bed of carbon. It was concluded that the constituent in the gas primarily responsible for the deterioration of the carbon was hydrocyanic acid, in the absence of which the rate of deterioration of the carbon was relatively slow.

Tests on a technical scale plant recovering benzole from 2 million c.ft. of coal gas per day have shown, however, that, even in the presence of hydrocyanic acid, increase in the working life of the carbon effected by improvements in the method of operating the plant was such that it is considered doubtful whether any further material improvement would be effected by removal of the hydrocyanic acid from the gas before entering the carbon filters.

The results of the most recent trials are summarized below.*

—	At Commencement.	After 168 Saturations.	After 550 Saturations.	After 934 Saturations.
Benzole yield per distillation (per cent. by wt. of carbon).	20	15	9	8·8
Average steam consumption (lb. per lb. of benzole) . .	2·2	2·4	3·0	3·5

The efficiency of extraction during these trials varied between 93 per cent. and 95 per cent., and, with proper supervision, was found to be independent of the loss in adsorptive capacity of the carbon.

These superior results are attributed chiefly to the passage of the steam and gas through the bed of carbon in opposite directions and the care taken that the benzole should not be left in contact with the carbon, particularly when hot, longer than necessary. Rapid removal of the adsorbed benzole was obtained by simultaneously heating the cold carbon by open steam and by steam coils. Complete removal of naphthalene from the gas entering the carbon filters during these trials was ensured by scrubbing with gas oil in a rotary scrubber, preliminary tests having shown that the use for this purpose of a prefilter containing active carbon was too costly.

Although these tests were carried out with gas produced from horizontal retorts, tests in an experimental plant showed equally satisfactory results with gas produced in vertical retorts, and also with low-temperature carbonization gas. The comparatively slow rate of deterioration with these gases is of particular interest in view of the higher proportions of unsaturateds present, and is doubtless attributable to the modifications introduced in the steaming process or to the lower concentration or absence of hydrocyanic acid in these gases.

The improvements effected as a result of this research appear to have gone a long way towards enabling this process to enter into competition with the existing and well established oil washing processes. The chief advantages of this method of benzole recovery over the latter processes are :—

(1) The direct recovery of benzole which is free from wash-oil and impurities derived from the wash-oil, thus reducing the costs of refining.

(2) A higher efficiency of recovery of the benzole from the gas.

(3) Smaller heat and power requirements.

Against these advantages must be set (1) the fact that the process is essentially intermittent, and labour and supervision charges will be higher, and (2) the success of the process depends to a large extent on the removal of naphthalene from the gas, which removal apparently can be accomplished economically only by means of an oil washer. If it is necessary to install an oil washer for naphthalene removal, the advantages of an active carbon plant are largely discounted, owing to the ease with which benzole recovery can be combined with the removal of naphthalene in a single washer.

REFINING.

In localities where it is difficult to dispose of the recovered benzole as crude, the troublesome refining process which has been necessary hitherto, before the crude product can be sold as motor spirit, has been a further factor which has operated against the recovery of benzole on gas-works. If the unsaturated hydrocarbons are not removed, the recovered product is liable to give unsatisfactory results when used in internal combustion engines, giving rise to gummy or resinous deposits in the induction manifold and on the inlet valve stems.

The normal method of refining employed up to the present has been to remove the unsaturateds completely or almost completely by washing the once-run benzole with a small quantity of sulphuric acid, whereby the unsaturateds are polymerized as "acid tar." After the removal of this acid tar the benzole is washed with water and then with caustic soda solution, and finally with water followed by redistillation. In order to obtain a really satisfactory product and avoid corrosion troubles, the quantities and concentrations of the acid used must be carefully regulated.[2]

A modification of this method of washing with acid, which possesses certain advantages over the usual method, is that known as the "Ufer" process.[3] In this method water is added to the mixture of benzole and acid tar, whereby the resinous substances formed by the acid treatment are separated from the acid tar and re-dissolved in the benzole. A dilute solution of sulphuric acid which can be used on the ammonium sulphate plant is also obtained. The resinous substances are separated from the benzole by redistillation, and can be returned to the tar storage tank. The chief advantages claimed are reduced refining losses, the absence of acid tar, which is difficult to dispose of, and the recovery without special apparatus of the acid used for refining. This method has given satisfactory results with gas-works and coke-oven benzoles, but does not appear to be applicable to all benzoles, owing to the formation of solid resins, when water is added to the mixture of benzole and acid tar.

As a result of an investigation of the mechanism of resin formation from benzoles containing unsaturateds, a method of producing a satisfactory motor benzole without removing the unsaturateds has been devised which thus considerably reduces the usual refining losses, and also the difficulties and expenses of refining.*

It was found that the gummy or resinous deposits formed in the induction system of engines run on benzoles containing unsaturateds are almost entirely due to the non-volatile polymerized material already formed which is in solution in the benzole at the time of use, and that little if any resinification of the volatile unsaturateds takes place in the engine. Thus it is the formation of the non-volatile material in the benzole from the unsaturateds during storage, which eventually leads to the troubles experienced with unrefined or incorrectly refined motor benzoles. With some benzoles the non-volatile material is formed rapidly on storage, while with others it takes place comparatively slowly. It was shown that the formation of the non-volatile resin was essentially an air oxidation process, and that the reactions involved were extremely sensitive to minute traces of certain impurities which are normally present in crude benzoles and which are capable of accelerating or retarding the oxidation of the unsaturateds and formation of resin. The impurities that accelerate resinification are usually acidic in character, while phenols are the most effective of those retarding resinification. By removing impurities of the former type and adjusting the concentration of phenols, it is possible to prepare benzoles which contain the whole of the unsaturateds normally present, and which can be stored for long periods without deterioration.

In practice the removal of accelerating impurities from most benzoles can be effected by washing the once-run benzole with dilute caustic soda. That this treatment also removes the phenols is of little consequence, since usually they are not present in the concentrations giving the maximum inhibiting effect. The once-run benzole is then refractionated, and a phenol, amino-phenol, or other substance capable of inhibiting the resinification of the unsaturateds is added in the optimum concentration to the motor benzole distillate during or immediately after refractionation. The quantity of an inhibitor which it is necessary to add depends chiefly upon the nature of the inhibitor, and it is preferable to use one which is volatile. When the cresols are used as inhibitors, the concentrations necessary are of the order of 0·03 per cent. by weight of the motor benzole distillate.

This method of stabilizing motor benzoles against resinification appears to be applicable to most benzoles. On certain works, however, the benzole has been found to contain impurities that are difficult to remove, and in consequence the addition of an inhibitor is rendered ineffective or only partially effective. Gas-works benzoles, which have been recovered from the purified gas, are in general freer from such impurities, and are more suitable for stabilization than coke-oven benzoles. Active carbon recovered benzole, owing to its freedom from impurities

* We are indebted to Mr. Hollings, Chief Research Chemist of the Gas Light and Coke Company, for these results.

* For a summary of the research carried out on this problem, since 1925, see Seventh Report of the Benzole Research Committee 1930.

derived from the wash-oil, also appears to be particularly suitable. With some benzoles it is only necessary to redistil the once-run benzole and add the inhibitor in order to produce a stable distillate.

Technical scale tests have been made by the Gas Light and Coke Company on this method of stabilizing gas-works benzoles containing unsaturateds. The results of storage tests on 6000 gallons of benzole stabilized by the addition of 0·03 per cent. by weight of tricresol are given in Fig. II., Curve 2, while the results of the corresponding storage tests on the same once-run benzole, which had been alkali washed and refractionated without the addition of tricresol, or refractionated only, are shown in Curves 1 and 3. Road trials carried out by the National Benzole Company, Ltd., on these benzoles showed that the stabilized benzole distillate when used after six to eight months storage was little, if at all, inferior to acid refined benzoles in their freedom from gumming in engines. These results have been confirmed during the past year by fleet trials, which have been carried out by the Gas Light and Coke Company, and which have given equally satisfactory results.

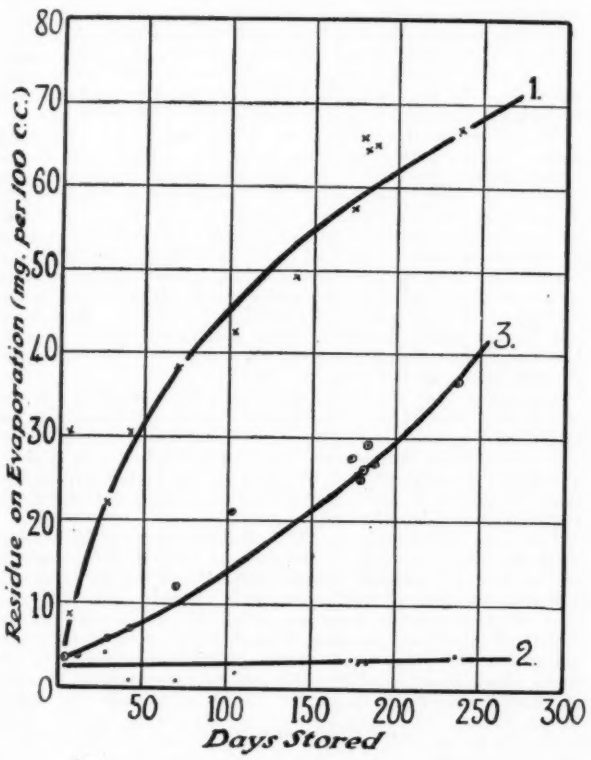

FIG. 2.

As previously pointed out, the advantages of this method of producing motor benzole are the conservation of the unsaturateds and the simplification and reduced expenses of the refining process. Against this must be set the fact that the unsaturateds, while present, are always a potential source of danger, and care has to be taken that stabilized benzole produced in this way is not contaminated during storage or handling with impurities, which may accelerate resinification or otherwise render the added inhibitor ineffective. If desired, however, the method could be modified by subjecting the benzole to a mild refining treatment for a partial removal of the least stable unsaturateds, followed by stabilization of the remainder.

The chief difficulty in the way of the general adoption of this and other methods of refining that aim at the conservation of the unsaturateds is the absence of a satisfactory test for showing whether a benzole will be stable on storage. The most satisfactory test so far devised is to subject the benzole to conditions of oxidation, and then determine the residue left on evaporation, but this test takes too long for routine purposes. There is reason to believe, however, that difficulties of this nature shortly will be overcome, so that the National Benzole Association will be enabled to alter the present motor benzole specification to permit benzoles containing unsaturateds to be utilized as motor fuel.

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DISCUSSION.

The PRESIDENT: I should like to thank the authors for their very interesting and valuable contribution. They have shown that if benzole were recovered at all gas-works the effect on the market would be negligible; also that benzole recovery, when adopted, becomes equivalent to finding a new consumer for 5 per cent. of the gas output who pays at a higher rate than any outside consumer of similar quantities. So far as our experience on one works in Leeds is concerned, the benzole plant in 1929 consumed the equivalent of 66,760,000 c.ft. of gas, and the price realized after deducting all overhead and working expenses of the benzole plant was approximately 3s. 3d. per 1000 c.ft.; the charge to an outside consumer using less than one-third of this amount is 2s. 3d. per 1000 c.ft. This will convey some idea of the attractiveness of benzole recovery.

The authors have dealt with the various methods used in the process of recovery and preparation of motor fuel, and modestly tell us that a method has been devised which will reduce materially both losses and costs in refining. Both the authors have done a considerable amount of work on this subject of inhibitors, and there are indications that their work has met with considerable success. I want to say that my benzole plant is open to inspection by anybody, as are also the monthly returns, to which we give careful consideration. I do ask you seriously to consider the points put forward by the authors.

Mr. F. FIRTH (Leeds): I wish to congratulate Mr. Hoffert on the able manner he has presented his paper. It is not my intention to criticize, but to emphasize the economical aspect of the subject. I think it is now generally accepted that the two bogies—naphthalene and drying of meter leathers—are not contemporary with benzole recovery. Naphthalene must be entirely removed from the gas to ensure freedom from troubles, and the benzole plant can be considered an aid to this end. Dry meter leathers are the result of the meter leather dressing becoming reduced in viscosity by absorption of light oils from the gas and draining from the leathers. As benzole recovery removes the light oils from gas, it should prove a remedy where dry meter leathers have been experienced. With these two bogies disposed of I feel there is no reason why benzole recovery should not be seriously considered by the majority of gas undertakings.

WE WANT REVENUE.

To-day we want revenue, and whether therms are sold as gas, liquid, or solid should not influence us in our endeavour to obtain business. To show how alert some undertakings are in finding means to increase revenue, two well-known undertakings are, at the moment, selling service for which gas is supplied without measurement, and the charge is a fixed one of 4d. per day. The principle underlying the enterprise would appear to be the same as that where benzole recovery is adopted—namely, securing a new consumer and finding an outlet for the extra therms of gas above their normal output that most works are capable of producing, and this costs little more than the coal and extra labour involved.

An analogy is electricity at ½d. per unit after the fixed charge has been met. One can argue that the expression is wrong; but the fact remains that if 200 units are consumed instead of 300 units, the saving is only 100 halfpennies, and similarly in working plant full out compared with partial working, the saving is limited to cost of coal and labour. Therefore the extra gas is cheap and this fact has been realized by the undertakings mentioned. But note the difference in the quantity of therms involved between the transactions mentioned and benzole recovery, although in both cases the underlying principles may be the same. In the one case the revenue from each installation is 2s. 4d. per week; in the other, for a 5 million a day works, the therms absorbed by a benzole recovery plant would be equal to a quarter of a million c.ft. per day, and the revenue from this quantity, after deducting all overhead and working expenses, would be approximately £270 per week. Even for this large consumption the price realized per 1000 c.ft. is considerably more than that where the revenue is only 2s. 4d. per week. Mr. Hoffert has also pointed

out that no holder and distribution charges are involved in benzole recovery, and also has indicated its usefulness by it being possible to divert the therms consumed by the plant into the holder in the case of a sudden demand from the district. Another advantage of a benzole recovery plant is that it is a consumer of low-grade fuel for steam raising. Our fuel bill for 1929 was £2074. This outlet for fuel will be appreciated by that section of the audience who have waste-heat boilers installed.

A PAYING PROPOSITION.

In addition to the reasons already advanced in favour of benzole recovery, I think it can be proved by gas manufacturing costs based on "Costs into Holder" that it is a paying proposition. It is well known that for a straight coal gas produced by any system the calorific value is around 550 B.Th.U. Therefore, except in less than half-a-dozen undertakings, whose declared calorific value is about this figure, the declared calorific value is obtained either knowingly or unknowingly by dilution—*i.e.*, steaming or other methods.

I gave a paper on benzole recovery which appeared in the issue of the "GAS JOURNAL" for Nov. 27, 1929, which included a "Cost Sheet" showing the costs of gas into the holder at a declared calorific value of 500 B.Th.U. with gas at an original calorific value of 523 B.Th.U. The methods of reduction being by—

1. Benzole recovery.
2. Dilution with producer gas.
3. Dilution with water gas.
4. Dilution with air.

The savings by the benzole recovery method for one month's working was £948 over the next lowest cost on a gas making plant producing approximately 5 million c.ft. of gas per day.

One of the reasons why benzole recovery has not been more generally adopted has been the accepted methods of examining the economics of the proposal—namely, one gallon of benzole is equal to 1·5 therms. 1·5 therms of gas at 9d. per therm = 1s. 1½d. The selling price of benzole is 1s. 5d. per gallon, leaving 3½d. to meet all overhead and working costs. Consequently it was rejected as unprofitable.

The greatest blunder in this reasoning is that it treats benzole recovery as an alternative to selling gas, whereas benzole recovery is a new consumer, and the amount absorbed would otherwise go into stock until the normal demand absorbed it. Again, a 5 p.ct. consumption of the works output without incurring holder and distribution charges is surely entitled to gas at a lower price than the consumer with an electric light and a gas boiling ring.

A more reasonable method of examining the proposal of benzole recovery is that given in the paper which is to take the price of a gallon of benzole at 1s. 5d. and deduct the costs of recovery, &c., which is approximately 6d. per gallon, leaving 11d. to pay for the 1½ therms removed from the gas. The return per therm is 7⅓d., and this price will compare favourably with the price paid by a consumer taking a similar amount. Mr. Hoffert has hinted that exception might be taken to costing the therms absorbed by the benzole plant at the cost of gas into holder, and on this point I feel emphatically that it is not a fair basis of charge. It is acknowledged that the costs of gas into holder are highest when there is a slump in the demand for gas, which is just the time when a substantial additional consumer would be a valuable asset. The position is paradoxical, for by debiting the recovery plant at "Costs into Holder" at this period the result might appear as a loss, and the benzole plant would be shut down when it is most needed.

MOST RELIABLE METHOD OF ASSESSMENT.

I suggest that the most reliable method of assessing the value of a benzole plant is to calculate the return realized per therm for the therms recovered as benzole after making all deductions for wages, materials, and overhead charges entailed in recovery, and, as the President has told us, the price realized per therm in Leeds for benzole recovered equalled 8·3d.

Before I sit down I would like to say that through the monumental work of Hollings, Pexton, and Chaplin on the absorption of benzole by active carbon, the work of the authors on inhibitors, and the hoped-for introduction of a test for the standard of purity to replace the sulphuric acid wash test, the savings in costs by eliminating rectification, &c., will make the recovery of benzole an attractive proposition for the smallest undertakings.

The PRESIDENT: I should like to mention that the Chief Constable of Leeds and the Chief of the Leeds Fire Brigade are here, and that they have passed our benzole plant as fireproof.

Mr. F. P. TARRATT (Newcastle-on-Tyne): I have been asked to discuss this question of benzole recovery. You are probably aware that at Newcastle we have practised benzole recovery for a considerable number of years; it is in vogue at two of our works where horizontal plants are in use. We recover about 3 gallons of benzole per ton of coal carbonized, and I can support the authors' statement that the cost is well under 6d. We keep a very accurate record of costs of benzole recovery and refining, and up to the present have not experienced any disadvantage whatever as the result of taking the benzole out of the gas. In the first instance we were somewhat concerned as to whether difficulties would arise in the distribution system, and particularly with regard to the meters; but I can assure you that our meters were never in better condition than they are at the present time. We use gas-oil for the recovery of benzole; indeed, it is used for a threefold purpose—it is used for naphthalene reduction, then for the extraction of benzole, and afterwards it is passed forward to the carburetted water gas plant. We are making a 550 or 560 B.Th.U. gas; the calorific value is reduced by about 25 B.Th.U. as the result of benzole extraction, and we have to adopt some other method in order to reduce the calorific value to the declared value of 500 B.Th.U. You have two processes to choose from—that in which you use gas-oil for washing, and the active carbon process. I do not think you need have the slightest hesitation in adopting benzole recovery and so doing your best to provide a considerable volume of fuel to replace some of that which is imported. We feel we are doing good work in this respect; during the last few years we have turned out a considerable quantity of benzole, and during the last twelve months it was about 350,000 gallons. We feel that the venture has been a very profitable one, and at the same time we are providing a fuel which is urgently needed for motoring and other purposes. I heartily endorse the points made by the authors. You have to bear in mind the point which has been raised with regard to the new customer, whose supply you can cut off at your discretion; he pays quite a good price for the product, even though you can cut him off during the period of peak loads.

Mr. HAROLD HOLLINGS (Gas Light and Coke Company) said: In their very interesting paper the authors refer to the active carbon process for the introduction of which into this country the Gas Light and Coke Company have been largely responsible. I should like to supplement and bring up to date the information quoted. In the first place, in order to prevent confusion, it must be pointed out that in their table of results the authors have quoted results obtained after 168 saturations which were published by me and my colleagues in the Transactions of the Institution of Chemical Engineers. As pointed out in our paper, however, those results related to another batch of carbon, and are not strictly comparable with the other results quoted by the authors.

The 9 per cent. yield obtained after 550 saturations was the latest result available at the time we wrote our paper for the Chemical Engineers. Further experience, however, has shown that the average results over a period were better than that. It will be appreciated that the fluctuations in the gas quality make it difficult to quote a representative result until after the completion of a lengthy run.

I am referring to this in a little detail because of its bearing upon the determination of the rate of depreciation of active carbon in use. Recently I have had all our results examined and a mean curve of the benzole yield plotted. This is shown in a diagram starting from an initial yield of 20 per cent. by weight of the carbon, passing through 8·8 per cent. at the 934th saturation and 7 per cent. at the 1200th saturation. On the same chart there is plotted the steam consumption at each distillation starting from 2·2 lbs. per lb. of benzole and rising to 3·9 lbs. at the 1200th saturation. By means of this chart it should be possible to calculate the useful working life of the carbon. The end of this may be determined by one of two circumstances. Either the steam consumption may rise to a point at which, having regard to local costs, it becomes no longer economical to work, or, alternatively, the benzole yield per saturation may fall so low that the frequency of operation of valves on the plant becomes too great for the normal operating staff. When either of these conditions arises it is necessary to replace the carbon. Under the conditions which obtain on the plant of the Gas Light and Coke Company, it is estimated that when the benzole yield per distillation falls to 4·5 per cent., it will be necessary to change the carbon in order to maintain reasonable operating conditions on the plant. From the slope of the curve which I have plotted it may be predicted that this stage will be reached after 1600 saturations. When it is completed the area of the curve will enable the consumption of carbon per unit weight of benzole to be calculated. It appears that this will be less than 6 lbs. per 1000 lbs. of benzole.

Over a period of six months the quantity of benzole recovered by this process amounted to 3·1 gallons per ton of Durham coal carbonized in horizontal retorts. This yield was based upon the whole of the coal carbonized on the works, and compares favourably with the average quoted by the authors.

The authors refer to the lower value of benzole produced in vertical retorts by reason of the higher paraffin content, and I should like to suggest that the value is also lower by reason of the greater refining cost resulting from the higher proportion of unsaturated hydrocarbons. I shall be interested to hear whether the reply of the authors to this observation is that this extra refining cost need not be incurred if an inhibitor is

XUM

used. I am in general agreement with what the authors say regarding the economics of benzole recovery, except that it does not appear to me that it can be claimed that the financial burden of carrying idle gas-making plant is reduced by the installation of a benzole recovery plant if it is also claimed that the cost into holder of the therms represented by benzole removal is to be exclusive of capital charges.

The reference to the benzole contained in carburetted water gas emphasizes the necessity for systematic work upon this subject. Our own work has been of a preliminary nature only, but it has been shown by Mr. W. A. Voss (J.S.C.I., 1927, 46, 373T) that the spirit has a high boiling-point range, and that it contains rather a higher proportion of unsaturated hydrocarbons which are particularly difficult to remove by acid washing. Thus unless a particularly efficacious inhibitor can be used it does not appear desirable to treat carburetted water gas. In some circumstances, however, it is more expedient to treat a mixture of coal gas and carburetted water gas, and for this reason the subject is worthy of further study.

The Plant at Hull.

Mr. H. E. Copp (President-Elect): Reference is made in the paper to recovery by oil washing and the advantages of tapping the crude benzole still for the removal of naphthalene. In 1915, I had occasion to instal a plant primarily for the recovery of toluole. Incidentally, of course, I had to recover benzole; quite a number of difficulties arose, but they were more or less overcome, and I ventured to describe them in a paper which I read before the Midland Association of Gas Engineers in 1918.

The objection to charging at the cost of gas to holder is that this would mean that recovery of benzole is most profitable when the cost of gas into holder is lowest—*i.e.*, when the gas-making plant is working at its maximum capacity. These conditions are unfavourable to benzole recovery. In order to reduce overhead charges, benzole recovery is most desirable when the demand for gas is lowest—*i.e.*, when the cost of gas into the holder is highest. The authors, therefore, avoid the difficulty and compare, without reference to detailed costs of gas production, the net price of benzole with the price at which the benzole is actually sold as therms in the gas. They give the total cost of recovery and refining as being about 6d. per gallon; as the selling price to-day is about 17d. per gallon, the net price is about 11d. per gallon. This, with a refining loss of from 5 to 10 per cent., is equivalent to a value of from 6d. to 7d. per therm in the gas. We have to consider whether it is worth while providing a new customer to take additional therms at 6d. or 7d. per therm—one who does not require a guaranteed supply of gas. I have very considerable doubts as to whether benzole recovery is actually profitable in the case of vertical retort gas. It is assumed that the decrease in calorific value has been compensated for by a decrease in the proportion of diluent gas, but I submit that this may not be true. Mr. Firth has shown that it is cheaper to adjust the calorific value of the gas by removing benzole than by dilution with air, producer gas, or blue water gas. The advantages of benzole recovery for the adjustment of calorific value do not appear to have been fully appreciated by gas engineers. When the straight gas (without benzole recovery) is mixed with diluent gas, this gas may be regarded as being carburetted with benzole, which is an expensive material compared with gas-oil.

The removal of naphthalene and benzole from the benzolized oil and the once-running operation can be combined in one operation by using a Sylvester or Holmes column on the stripping still. The total removal of naphthalene demands separate washers for benzole recovery and naphthalene removal.

I have not personal experience of the use of active charcoal, but I take it that its advantages are:

(1) Refining costs less, since the crude benzole is free from wash-oil.

(2) The efficiency of the recovery of benzole from the gas is higher.

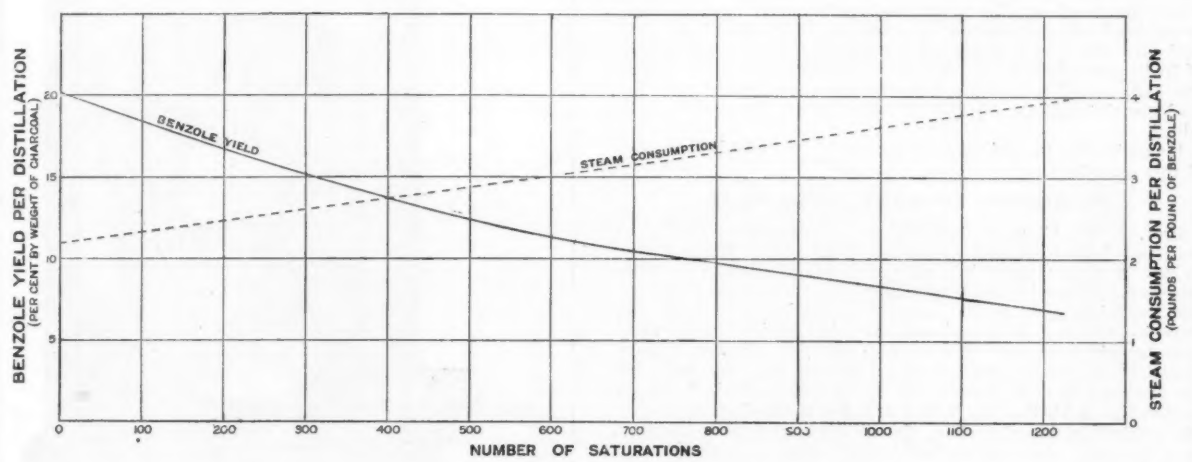
(3) The heat and power requirements are smaller.

On the other hand, I take it that the disadvantages are that:

(1) Labour and supervision are much more expensive, as the process is intermittent; and

(2) It is essential to remove naphthalene, whereas a single washer can be used in the oil-washing process.

Mr. R. N. Webb (Manager of the Meadow Lane Gas-Works, Leeds) in response to the President's invitation to speak, said: I have collaborated with Mr. Firth all the way through in the benzole washing at our works. We first started in 1915 to wash our gas for benzole and toluole for war purposes. I will not say that we experienced trouble at the beginning, but possibly we thought we had found trouble, inasmuch as, naturally, our make per ton—which I will be honest enough to say was rather a fetish at that time—was reduced, and, in my capacity as Works Manager, I was a little worried about that. However, perhaps a good deal of our trouble was attributed at that time, not merely to benzole washing, but to the class of coal we were receiving. What I would like to assure you of is that benzole recovery, so far from being a source of worry and trouble to a gas-works manager, has rather the opposite effect; there is no trouble at all in connection with the working of the benzole plant. One of its advantages is that by its use a gas-works with horizontal retorts becomes a very elastic unit; it enables one to carbonize coals of very different qualities. While maintaining the maximum benzole recovery per ton we can, even with the worst of coals we receive, supply our 470 B.Th.U. gas extremely regularly. Naphthalene troubles, instead of being accentuated, are practically things of the past so far as Leeds is concerned. When we first started using the benzole plant we did rather accentuate the naphthalene troubles, but, of course, whenever we instal new plant in a works, we must look upon it broadmindedly; we must expect some troubles and apply ourselves to overcoming them, as we have overcome our naphthalene troubles. In the very near future, perhaps, we shall be drying our gas—and in my opinion that is the very best method of dealing with it. I should like to emphasize, for the benefit of those who have not been concerned with benzole plant, that they need have no fears with regard to it, and in my opinion a benzole plant is a very remunerative proposition.



Benzole Recovery Pays in Gas-Works.

Mr. L. H. Sensicle: I am entirely in agreement with those who say that benzole recovery does pay in gas-works—and I find it difficult to conceive of circumstances in which there can be any serious doubt about that matter. In order to arrive at a figure representing the credit to be obtained from benzole recovery, it is always necessary to assume the value of the gas

into the holder as the equivalent value of the benzole when expressed as gaseous therms. The price of gas to the town, to my mind, has nothing to do with the question; if we consider the question of distribution we shall find that the cost of distributing benzole is practically nothing, whereas the cost of distribution of gas is fairly high. I agree with previous speakers who questioned the figure of 6d. per gallon as representing the cost of recovering and refining benzole; in my experience the cost is usually lower than that. Reference has been made by Mr. Tarratt to the very interesting installation at Newcastle, but he did not mention one point which has some bearing on the economic work of that plant. There is a statement in the paper that the variations in gas output do not lend themselves to economic benzole recovery; apparently the authors assume that the changes in the volume of gas to be passed through the scrubbers operate against economic working. In this connection I would point out that at one of the works at Newcastle there are two different sizes of installations of benzole scrubbers, and it is thus possible to work with plant of any of three different capacities at any time—*i.e.*, it is possible to operate the small plant by itself, the large one by itself, or both of them together. In that way we can always have an approximately economic condition of benzole scrubbing.

It is stated in the paper that in coke oven practice tar fog is liable to give trouble in benzole extraction, and the inference is that that trouble does not occur in gas-works practice. I think it will be agreed, however, by those who have had experience of coke oven practice, that tar fog removal is better in coke oven recovery plants than in gas-works, for the simple reason that it is common to instal special tar extractors, which are usually of the mechanical type. Sludge formation does occur in benzole recovery at gas-works when gas oil is used, and it is also quite common to wash unpurified gas at gas-works for benzole. In one particular case this is necessary because carburetted water gas has to be added to the main stream of gas before purification. To purify carburetted water gas by itself is not such an easy matter as purifying it in admixture with coal gas, the reason being, of course, the lower concentration of hydrogen sulphide; so that if one wishes to avoid washing the carburetted water gas from benzole one has to pass the coal gas through the benzole scrubbers before the water gas is added.

I should like to add that I appreciate very much the value of this contribution.

Far-Reaching Importance of the Paper.

Prof. J. W. Cobb, C.B.E. (Livesey Professor of Coal Gas and Fuel Industries at the University of Leeds): What I have to say is rather more in the nature of congratulation than criticism. In the laboratories at the University of Leeds I have had the privilege of seeing some of the authors' work on this benzole problem. It is evident that the production of more benzole, which means more motor spirit, is a matter of great national importance, and a very suitable matter, obviously, for the National Benzole Association to take seriously in hand, in conjunction with the gas industry. One method of increasing the production is, of course, the absorption of more benzole from the gas. Another method is that of treating the benzole when it has been recovered from the gas—which is not wasteful. The standard method at the present time is one which was devised, not for the production of motor spirit, but for chemical purposes, in which the requirements were very much more stringent than are necessary in regard to motor spirit. That is realized to-day, and a large number of attempts are being made to substitute less drastic processes. After all, the great thing that has to be prevented, once the volatility of the spirit is assured, is the evil of gumming, and half of the paper presented by Mr. Hoffert and Mr. Claxton deals with what I believe is a research of most fundamental and far-reaching importance and value in that connection. The authors have not made it quite clear how far-reaching is the process they describe for preventing the gumming of motor spirit by the use of inhibitors, and so allowing a much larger proportion of the motor spirit to be used, and that it is due to a research for which they and the Joint Benzole Research Committee are directly responsible. In justice to the authors, I think that that might be made clearer than it has been made in the text of the paper.

The Author's Reply.

Mr. Hoffert, replying to the discussion, said: When we were asked to prepare this paper we felt that the subject was very contentious, and we expected that there would be a lot of opposition; but all the speakers appear to be in favour of benzole recovery, and it only remains for the gas industry to go ahead and to increase the amount of benzole produced at the gas-works. I have not time now to deal adequately with the questions that have been asked, but perhaps I shall be able to deal with them in a written reply. With regard to the suggestion that the figure of 6d. per gallon as representing the cost of recovering and refining benzole is rather high, however, I think I have admitted this. At the same time, I would ask you to note that that price is the cost per gallon of "refined" motor benzole and not the cost per gallon of crude; I believe some people have assumed the latter.

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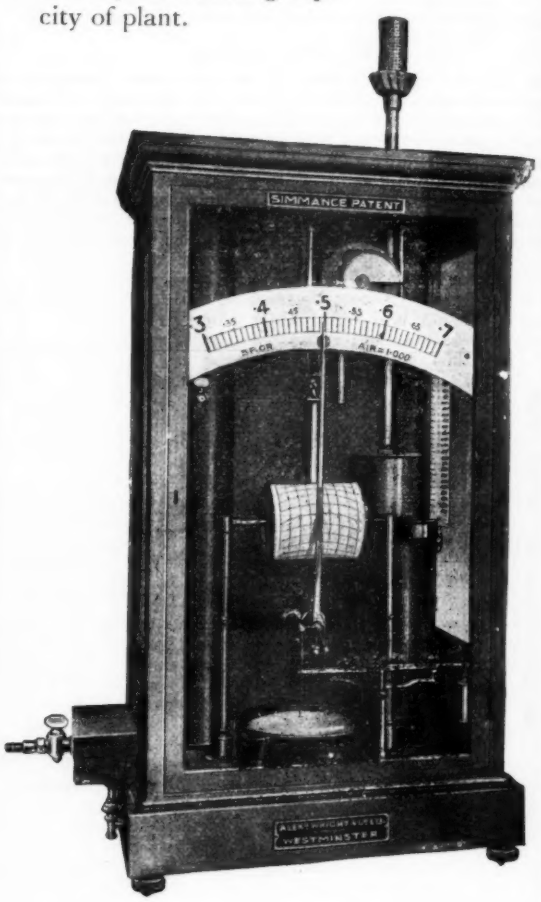

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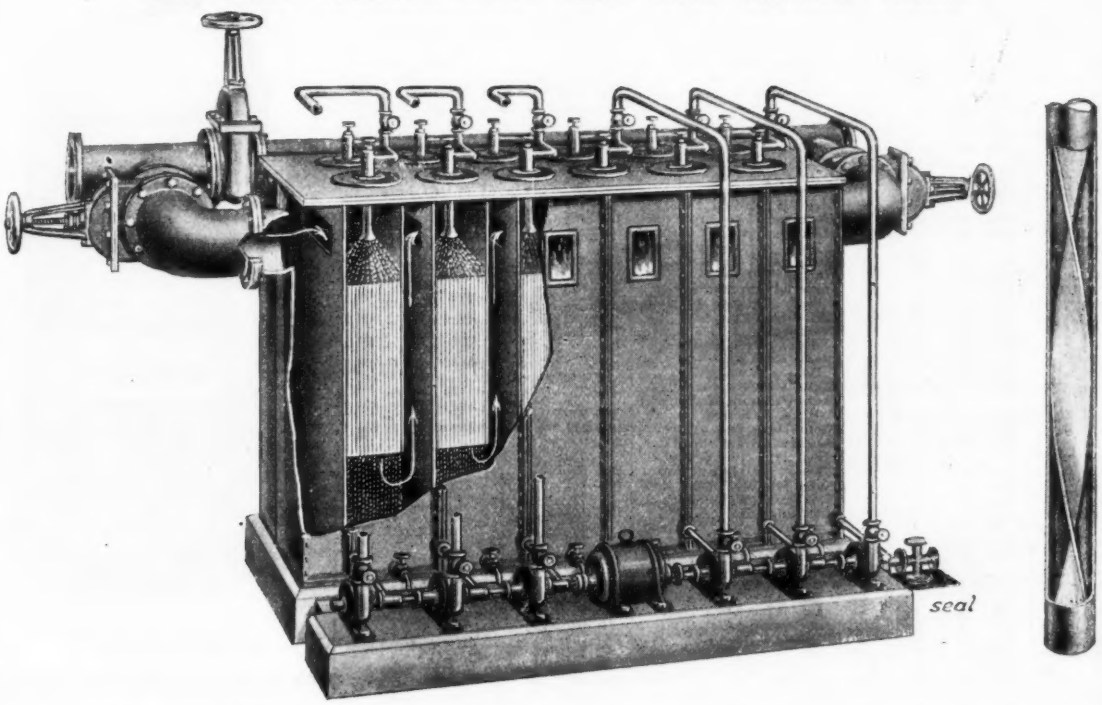

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[For Stock Market Report, see earlier pages.]

Issue.	Share.	When ex-Dividend.	Dividends. Prev. Hf. Yr.	Dividends. Last Hf. Yr.	NAME.	Quotations. June 6.	Rise or Fall on Week.	Transactions Lowest and Highest Prices During the Week.
£			% p.a.	% p.a.				
171,978	Stk.	Feb. 6	8	8	Aldershot 8 p.c. max. C. .	73—78	..	..
522,992	,,	,,	4	4	Do. 4 p.c. Pref. . .	70—73	..	71½
1,551,868	,,	Apl. 3	7⅞	7⅞	Alliance & Dublin Ord. . .	94—97	..	94½—95
374,000	,,	Jan. 9	4	4	Do. 4 p.c. Deb. . . .	60—63	..	..
522,655	,,	Mar. 6	7	7	Barnet Ord. 7 p.c. . . .	109—112	..	..
300,000	1	Apl. 24	1/4½	1/7½	Bombay, Ltd.	16/6 -18/6	..	..
174,500	10	Mar. 6	9	9	Bournemouth 5 p.c. . . .	14—15	..	14¼
500,050	10	,,	7	7	Do. B 7 p.c. . . .	12¼—12⅝	..	..
439,160	10	,,	6	6	Do. Pref. 6 p.c. .	10⅝—11½	..	..
50,000	Stk.	Dec. 19	3	3	Do. 3 p.c. Deb. .	55—58	..	..
162,025	,,	,,	4	4	Do. 4 p.c. Deb. .	74—77	..	..
357,900	,,	Mar. 20	7½	7½	Brighton & Hove 6 p.c. Con.	114—117	..	115½—116½
871,880	,,	,,	6⅝	6⅝	Do. 5 p.c. Con.	102—105	..	..
1,287,500	,,	Feb. 20	5	5	Bristol 5 p.c. max.	88—89a	..	..
855,000	,,	Apl. 3	7	8	British Ord.	110—115	..	..
100,000	,,	Dec 19	7	7	Do. 7 p.c. Pref. . . .	115—120	..	..
120,000	,,	,,	4	4	Do. 4 p.c. Red. Deb. .	72—75	..	..
450 000	,,	,,	5	5	Do. 5 p.c. Red. Deb. . .	92—95	..	..
100,000	,,	Jan. 9	5	5	Cambridge 5 p.c. Deb. . .	94—97	..	95½
100,000	10	May 22	6	10	Cape Town, Ltd.	8½—9¼	..	..
100,000	10	Apl. 24	4½	4½	Do. 4½ p.c. Pref. . .	6¾—7½	..	..
150,000	Stk.	Dec. 19	4½	4½	Do. 4½ p.c. Deb. . .	71—76	..	..
626,860	,,	Feb. 20	6	6	Cardiff Con. Ord.	96—99	..	..
237,860	,,	Jan. 9	7½	7½	Do. 7½ p.c. Red. Deb. .	98—101	..	..
157,150	,,	Feb. 20	5	6½	Chester 5 p.c. Ord.	88—93b	..	..
98,936	1	May 8	†2/-	†2/-	Colombo, Ltd. Ord.	33/—35/-	..	..
24,500	1	,,	1/4½	1/4½	Do. 7 p.c. Pref. . .	18/6—20/6	..	..
375,402	1	Apl. 3	1/9½	1/9½	Colonial Gas Assn. Ld. Ord	20/—22/-	..	..
187,848	1	,,	1/7½	1/7½	Do. 8 p.c. Pref.	19/—21/-	..	..
2,073,280	Stk.	Feb. 20	5	7	Commercial Ord.	90—93	..	91½—92½
475,000	,,	Dec. 19	3	3	Do. 3 p.c. Deb. . .	57—60	..	..
787,560	,,	Feb. 20	7	7	Croydon sliding scale. . .	105—108	..	106½—107½
453,100	,,	,,	5	5	Do. max. div. . . .	83—86	..	84½
542,270	,,	Mar. 6	7	10	Derby Con.	115—125e	..	..
55,000	,,	Dec. 19	4	4	Do. Deb.	67—70e	..	..
209 000	,,	Mar. 6	5	5	East Hull Ord. 5 p.c. . . .	71—73	..	..
1,002,180	10	Mar. 20	4	†7	European, Ltd.	12½—13¼	—1	12⅝—13
18,629,125	Stk.	Feb. 20	5⅝	5⅝	Gas Light & Coke 4 p.c. Ord.	18/9—19/3f	..	18/10½ - 19/1½
2,600,000	,,	,,	3½	3¾	Do. 3½ p.c. max. . . .	63½—65½	..	64½—65
4,157,020	,,	,,	4	4	Do. 4 p.c. Con. Pref. . .	77—80	..	77½—78½
5,602,620	,,	Dec. 19	3	3	Do. 3 p.c. Con. Deb. . .	59—62	..	60¼—61½
3,642,770	,,	,,	5	5	Do. 5 p.c. Red. Deb. . .	99—102	..	..
161,460	,,	Feb. 20	10	10	Harrogate Cons. 10 p.c. max.	158—163	..	..
82,500	,,	Mar. 20	7	7	Hastings & St. L. 5 p.c. Conv.	96—101	..	..
258,740	,,	,,	5½	5½	Do. 3½p.c. Conv.	78—83	..	..
70,000	10	May 22	†10	§	Hongkong & China, Ltd. .	13½—14½	..	..
213,200	Stk.	Mar. 6	6	6	Hornsey Con. 3½ p.c. . . .	90—93	..	..
2,436,594	,,	May 22	10	25	Imperial Continental Cap. .	355—375	+5	356½—367
223,130	,,	Feb. 6	3¼	3½	Do. 3½ p.c. Red. Deb.	80—85	..	..
235,242	,,	Mar. 20	8½	8½	Lea Bridge 5 p.c. Ord. . .	123—128	..	..
2,145,907	,,	Feb. 20	6	6	Liverpool 5 p.c. Ord. . . .	91½—94¼b	..	..
600,000	,,	Mar. 20	7	7	Do. 7 p.c. Red. Pref. .	100—102b	..	..
165,736	,,	Feb. 20	9	8	Maidstone 5 p.c. Cap. . .	119 -124	..	..
63,480	,,	Dec. 19	3	3	Do. 3 p.c. Deb. . .	52—55	..	..
75,000	5	Dec. 5	†10	†10	Malta & Mediterranean . . Metrop'itan (of Melbourne)	5½—6	..	..
392,000	—	Apl. 1	5½	5½	5½ p.c. Red. Deb. . . .	90—93	..	..
541,920	Stk.	May 22	†6	†8	Montevideo, Ltd.	107—112	..	..
2,061,315	,,	Feb. 20	5	5½	Newcastle & Gateshead Con.	16/3—16/9d	..	..
682,856	,,	,,	4	4	Do. 4 p.c. Pref. .	70—71d	..	..
691,705	,,	Dec. 19	3½	3½	Do. 3½ p.c. Deb. .	66⅜—67½d	..	..
169,940	,,	Mar. 6	7¼	7¼	North Middlesex 6 p.c. Con.	109—114	..	111¼
396,160	,,	Feb. 6	5	5	Northampton 5 p.c. max. .	74—77	..	..
300 000	,,	Apl. 24	9	7	Oriental, Ltd.	108—113	..	..
60,000	5	13 My., '15	—	—	ttoman	0—½	..	..
205,162	Stk.	Jan. 9	8	8	Plym'th & Stonehouse 5 p.c.	107 110	..	..
424,416	,,	Feb. 20	8	8	Portsm'th Con. Stk. 4 p.c. Std	110—115	..	..
241,446	,,	,,	5	5	Do. 5 p.c. max. . .	78—81	..	..
186,000	100	June 2	4	4	Primitiva 4 p.c. Red. Deb. .	94—97*	+2	..
677,837	Stk.	Jan. 23	4	4	Do. 4 p.c. Red. Deb. 1911	81 -84	..	82½
371,496	,,	Dec. 19	4	4	Do. 4 p.c. Cons. Deb. .	81—84	..	..
150,000	10	Apl. 3	6	6	San Paulo 6 p.c. Pref. . .	8½—9	..	..
1,736,968	Stk.	Mar. 20	6½	6½	Sheffield Cons.	103—105e	..	..
95,000	,,	Jan. 9	4	4	Do. 4 p.c. Deb. . . .	76—78e	..	..
90,000	10	June 5	‡4	‡	South African	4—6*	..	..
6 709.895	Stk.	Feb. 20	5	7½	South Met. Ord.	102—104	..	102½—103½
500,000	,,	,,	6	6	Do. 6 p.c. Irred. Pf.	107—110	..	..
1,895,445	,,	Jan. 9	3	3	Do. 3 p.c. Deb. . .	58—61	..	60
734,000	,,	Mar. 6	6½	6½	Do. 6½ p.c. Red. Db.	99—101	..	..
91.500	,,	Mar. 20	8½	8½	South Shields Con. . . .	106½—107½d	..	..
1.543,795	,,	Feb. 20	6½	6½	South Suburban Ord. 5 p.c.	101—104	..	103
468,837	,,	Dec. 19	5	5	Do. 5 p.c. Deb.	95—98	+2	94½
647.740	,,	Feb. 20	5	5	Southampton Ord. 5 p.c. max.	76—79	..	..
121 275	,,	Dec. 19	4	4	Do. 4 p.c. Deb.	72—75	..	..
179,014	,,	Feb. 20	8	8	Sutton Ord.	113—116	..	..
67,828	,,	Jan. 9	5	5	Do. 5 p.c. Deb. . . .	93—96	+1	..
250,000	,,	Mar. 6	7	7	Swansea 7 p.c. Red. Pref. .	98—100	..	99
200,000	,,	Dec. 19	6½	6½	Do. 6½ p.c. Red. Deb. .	99—101	..	..
1,076,490	,,	Mar. 6	6⅝	6⅝	Tottenham District Ord. .	102—106	+1	104 -104½
150,000	,,	,,	5½	5½	Do. 5½ p.c. Pref. . .	97—100	+2	..
199,005	,,	Dec. 5	4	4	Do. 4 p.c. Deb. . .	73—76	..	..
182,380	10	30 Dec., '12	—	—	Tuscan, Ltd.	3¾—4¾	..	..
85,701	Stk.	Mar. 20	6	6	Do. 6 p.c. Red. Deb. Uxbridge, Maidenhead, &	75—80	..	..
309,094	,,	Mar. 6	7	7	Wycombe 5 p.c.	94—99	..	..
88,395	,,	,,	5	5	Do. 5 p.c. pref. . .	85—90	..	..
1,180,970	,,	—	—	—	Wandsworth, Wimbledon, and Epsom Cons. . .	108—113	..	111½—111¾
200,000	,,	Feb. 20	5	5	Do. 5 p.c. Pref. . . .	87—92	+2	..
488,344	,,	Dec. 19	5	5	Do. 5 p.c. Deb. . . .	95—98	+2	..

Quotations at:—*a.*—Bristol. *b.*—Liverpool. *c.*—Nottingham. *d.*—Newcastle. *e.*—Sheffield. *f.*—The quotation is per £1 of Stock. * Ex. div. † Paid free of income-tax. ‡ For year. § Div=10 p.ct. p.a. less tax and less tax on interim dividend.

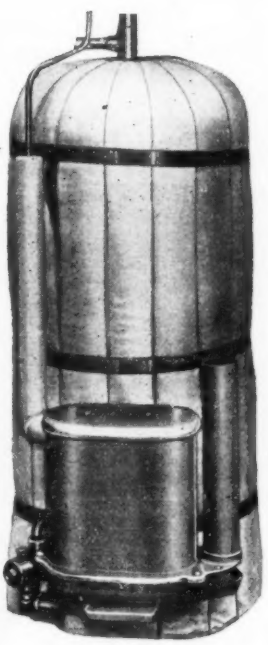
A LONG FELT WANT

GENERAL

IMMERSION INDIRECT WATER HEATER

Works with Existing Hot-Water Systems.

HARD AND SOFT WATER TROUBLES DISAPPEAR!



NO CONDENSATION
NO CORROSION OF INTERNAL FLUES
NO DISCOLORATION OF WATER
NO DEPOSIT IN THE FLUE
NO DEPOSIT IN THE BOILER
LAGGING—VERMIN PROOF

Illustrated List on Application to

GENERAL GAS APPLIANCES LIMITED

Guide Bridge Manchester

NOTICES TO CORRESPONDENTS, ADVERTISERS, AND SUBSCRIBERS.

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Orders to Alter or Stop PERMANENT ADVERTISEMENTS should be received by the FIRST POST on Monday.

UNDISPLAYED ADVERTISEMENTS: Situations Wanted, Six Lines and under (about 36 words), 3s.; each additional Line, 6d. Situations Vacant, Apparatus Wanted and for Sale, Contracts, Public Notices, &c., 9d. per Line—minimum, 4s. 6d. An additional charge of 6d. is made where replies are addressed c/o the "JOURNAL."

TERMS OF SUBSCRIPTION to the "JOURNAL."

(Continuous Subscribers are entitled to a free copy of the "GAS JOURNAL" CALENDAR and DIRECTORY.)

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United Kingdom & Ireland	Advance Rate:	35/-	18/-	10/-
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All Communications, Remittances, &c., to be addressed to WALTER KING, LIMITED, 11, BOLT COURT, FLEET STREET, LONDON, E.C. 4.

Gas Purification & Chemical Company, Limited

— ESTABLISHED 1873 —

PALMERSTON HOUSE, 34, OLD BROAD STREET, LONDON, E.C.2

Gas Purification Contractors

WILL SUPPLY

Oxide of Iron

on Sale Outright
or on Loan Contract

AND PURCHASE

Spent Oxide

Per Contra or Separately.
London or Provinces
Samples Tested Free

Telegrams: "Purification, Stock, London."
Telephone: London Wall 9144.

SATURATORS

FOR producing Long Needle-like CRYSTALS; also plant for producing NEUTRALIZED SULPHATE.

THE CHEMICAL ENGINEERING AND WILTON'S PATENT FURNACE Co., Ltd.
76, Victoria Street, London, S.W. 1.
(See also advertisement p. 785.)

Telephone: VICTORIA 2417. Telegrams: "EVAPORATOR PHONE LONDON."

GAS WORKS STEAM PLANT.

We can meet your requirements for BOILERS, RECEIVERS, TANKS, WASHER TUBES, SIZING SCREENS, PLATE WORK, BOILER SETTINGS, CHIMNEYS (brick and steel).

INQUIRIES INVITED.

H. & T. DANKS (NETHERTON) Ltd., NETHERTON, DUDLEY.
(See page advert., Centre p. XI.)

SULPHURIC ACID.

SPECIALLY prepared for the manufacture of SULPHATE OF AMMONIA.

SPENCER CHAPMAN & MESSEL, LTD.,
with which is amalgamated WM. PEARCE & SONS, LTD., Walsingham House, Seething Lane, LONDON, E.C.3.
Works—SILVERTOWN.
Telegrams—"HYDROCHLORIC, FEN LONDON."
Telephone—ROYAL 1166.

THE BRITISH GAS PURIFYING MATERIALS CO., LTD.,
99, LONDON ROAD, LEICESTER.
Telegrams: "BRIPURIMAT, LEICESTER." Telephone: LEICESTER 5096.

Solicit enquiries for:
NATURAL BRITISH PURIFYING MATERIAL,
NATURAL HYDRATED OXIDE OF IRON,
FIRST QUALITY DUTCH BOG ORE,
BEST QUALITY BELGIAN BOG ORE,
"PREPARED" AND "UNPREPARED" ARTIFICIAL OXIDES.

SPENT OXIDE PURCHASED.

LONDON OFFICE:
226, BISHOPSGATE, E.C.2.
Telegrams: "BRIPURIMAT AVE. LONDON." Telephone: BISHOPSGATE 8656.

J. & J. BRADDOCK (Branch of Meters Limited), Globe Meter Works, OLDHAM, and 45 & 47, Westminster Bridge Road, LONDON, S.E. 1.

WET AND DRY GAS METERS, PREPAYMENT METERS, STATION METERS AND GOVERNORS.

REPAIRS RECEIVE PROMPT ATTENTION.

Telephones: 815 Oldham, and 2412 Hop, London.

Telegrams: "BRADDOCK, OLDHAM," and "METRIQUE, LAMB, LONDON."

MEWBURN, ELLIS, & CO.,
CHARTERED PATENT AGENTS AND TRADE MARK AGENTS,
70 & 72, Chancery Lane, London, W.C. 2.
Telegrams: "Patent, London." Phone: 243 Holborn.
And 3, St. Nicholas Buildings, Newcastle-on-Tyne.

WEIGHBRIDGES

FOR Motor Lorries and Railway Traffic can be seen erected at our Works READY FOR DELIVERY. Inspection by your Engineer invited and a test by your Local Inspector of Weights and Measures before delivery. Every machine a High-Class Engineering Product and fully guaranteed.

CHARLES ROSS, LIMITED,
SHEFFIELD.

SULPHURIC ACID.

JOHN RILEY & SONS, Limited, Chemical Manufacturers, Accrington, Lancs., P.B.O. Box No. 62, are MAKERS of Special SULPHURIC ACID ("Eagle" Brand), for Sulphate of Ammonia Making. Highest percentage of Sulphate of Ammonia obtained from the use of this Vitriol, which has now been used for upwards of 80 years. Reference given to Gas Companies.

APPOINTMENTS, &c., WANTED.

EXPERIENCED Lecturer and Demonstrator in Cooking by Gas can give LOCAL DEMONSTRATIONS for Gas Undertakings.

Gas Engineers should apply now for vacant dates to Miss H. H. TUXFORD, M.C.A., "WESTWOOD," TATTERSHALL, LINCOLN.

APPOINTMENTS, &c., VACANT.

CITY OF COVENTRY.
(GAS DEPARTMENT.)

APPLICATIONS are invited for the Position of INDUSTRIAL GAS EXPERT at a Salary of £400 per Annum, rising by annual increments of £10 to £500 per Annum.

The appointment will be subject to the provisions of the Local Government, &c., Superannuation Act, 1922, and the Candidate appointed will be required to pass a medical examination.

Applicants must have received a sound Technical Training, also practical experience in the application of Gas for Industrial Purposes, and be competent to Consult with, and advise, Plant Engineers in large factories as to the most efficient manner in which gas may be utilized in any process of heat treatment.

Applications, stating Age, giving full particulars as to Training and Practical Experience, together with *copies* of Testimonials, to be addressed to the undersigned not later than the 19th of June, 1930, endorsed "Industrial Gas Expert."

P. N. LANGFORD,
Engineer and General Manager.

Gas Department,
Coventry,
May 30, 1930.

OXIDE OF IRON.
SPENT OXIDE BOUGHT.

BALE & CHURCH, LTD.,
33, ST. MARY AT HILL, LONDON, E.C.3.
Phone: Royal 1484.

"TORTO" FIRE CEMENT.

BALE & CHURCH, LTD.,
33, ST. MARY AT HILL, LONDON, E.C.3.
Phone: Royal 1484.

"KLEENOFF," THE COOKER CLEANSER.
Tins for Sale to Consumers.
In Bulk for Works Use.
(See "Gas Salesman.")

BALE & CHURCH, LTD.,
33, ST. MARY AT HILL, LONDON, E.C.3.
Phone: Royal 1484.

MANCHESTER OXIDE CO., LTD.
MILES PLATTING,
MANCHESTER.

TEL.: OXIDE, MANCHESTER. ESTABLISHED 1890.

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FRESH OXIDE {ON SALE / OR LOAN.

BRITISH MAKE.
IMMEDIATE DELIVERY.
NO EXCESS MOISTURE.
IMMEDIATE ACTIVITY.
MINIMUM BACK PRESSURE.
MINIMUM EXPOSURES.
MINIMUM LABOUR.

SPENT OXIDE PURCHASED
ON SULPHUR CONTENT.
ON **BLUE** CONTENT.

SPECIALISTS IN PURIFICATION.

GAS PURIFIED IN 1929
OVER 46,000 MILLIONS.

THE Portsmouth Gas Company invite APPLICATIONS for the POSITION of SECRETARY.

Commencing Salary, not less than £800 per Annum.

Age 32 to 42 years.

Applicants must have had a sound Accountancy and Secretarial Training and Experience. The successful candidate will participate in the Contributory Superannuation Benefit and will be required to pass a Medical Examination.

Applications, giving Age, full Particulars of Training and Experience, should be accompanied by *copies* of two recent Testimonials and received by the Chairman of the Company, in an envelope endorsed "Secretary," not later than the 16th of June, 1930.

T. CARMICHAEL,
Engineer and General Manager.

The Portsmouth Gas Company,
Chief Offices,
The Square, Portsmouth,
May 26, 1930.

XUM

ROBERT DEMPSTER & SONS, Ltd., ELLAND, Builders of CARBONIZING PLANTS, both Horizontal and Vertical. Manufacturers of CONDENSERS, PURIFIERS, GASHOLDERS, &c., also every description of COAL and COKE HANDLING PLANT. Telegrams: "DEMPSTER, ELLAND." Telephone: ELLAND 261 (Private Branch Exchange).

EXTENSIONS and Renewals. Ask us to quote before ordering GAS APPARATUS, COKE-OVEN PLANT, STRUCTURAL STEELWORK. Competitive prices. First-Class Workmanship. Satisfaction Guaranteed.
FIRTH BLAKELEY, SONS, & CO., LTD., CHURCH-FENTON, YORKSHIRE.

STRACHAN & HENSHAW LTD., BRISTOL.
MANUFACTURERS and CONTRACTORS for
HANDLING PLANT, SCREENS, TIPPLERS, ETC.

WATER-GAS PLANT
ECONOMICAL GAS APPARATUS CONSTRUCTION COMPANY, LIMITED.
22, Carlisle Place, London, S.W.

APPOINTMENTS, &c., VACANT.

(Continued.)

REQUIRED by large Gas Undertaking near London, GENERAL FITTINGS FOREMAN, for Controlling District and Fittings Staff. Must be practical man with good knowledge of all up-to-date Gas Apparatus. Good disciplinarian.
State Age and Wages required to No. 8075, "GAS JOURNAL," 11, BOLT COURT, FLEET STREET, E.C. 4.

PLANT &c., FOR SALE & WANTED.

PLANT FOR SALE.

GASHOLDER & Steel Tank, Column Guided, 27,000 capacity, with Cup for another Lift. Good Condition. Tempting price before removal.
Purifiers.—Dry Lute Type. Two Sets of Four, 10 ft. square; with Lifting Gear, Valves, &c.
Meters.—Two Rectangular Station Meters fitted with New Drums, 15,000 c.ft. per hour capacity.
Cylindrical Station Meters, 15,000, 10,000, 4000, 3600, and 2000 c.ft. capacities and smaller.
Station Governors.—Parkinson, Cowan, Braddocks, and Peebles, 4 in., 6 in., 8 in.
Retort Ironworks for beds of 4's, 5's, 6's, 7's, and 8's. 22 in. by 16 in. Self-Sealing Mouthpieces. 6 in. Ascension Pipes and all to follow.
Washers and Tar Extractors—Livesey and Cripps type. 2 million, 250,000, and 200,000 c.ft. per day.
Kirkham Standard Washer-Scrubber, 350,000 c.ft. per day, 10 in. diameter bye-pass.
Exhausting Sets.—Steam and Gas Engine-driven, 5000 to 40,000 c.ft. per hour capacity.
Vertical Boiler.—7 ft. 6 in. by 3 ft. 3 in. diameter, 80 lbs. pressure, all fittings.
Storage Tanks—Large number in Stock (Rectangular and Cylindrical). Tar Stills, &c.
Tar and Liquor Pumps, Steam and Belt-Driven.
Air Receivers, Fans, Blowers, Valves, Rivetted Tubes.
Firth Blakeley, Sons, & Co., Ltd.
(Second-Hand Plant Dept.),
Vulcan Ironworks, Church-Fenton, Leeds
Telephone: 14, South Milford. Telegrams: Blakeleys Church-Fenton.

TWW

NEW AND RE-CONDITIONED MACHINERY.
ABOUT 80 Unused Stock-rusty Rolled STEEL JOISTS, each 30 ft. long by 15 in. by 6 in. section, of British Manufacture, weighing about 59 lbs. per lineal foot. Ready for immediate despatch. At Low Prices for Quick Clearance!
Ask for "Albion" Machinery Catalogue. Post free on application.
THOS. W. WARD, LIMITED,
ALBION WORKS, SHEFFIELD.

GAS-WORKS Plant. We Purchase, for Dismantling, for Re-Use or Scrap, any DISCARDED PLANT or IRONWORK. Best prices, prompt removal by experienced staff, covered by insurance for all risks.
FIRTH BLAKELEY, SONS, & CO., LTD., Second Hand Plant Department, CHURCH-FENTON, *via* LEEDS.

FOR SALE—20,000 Gallons of De-HYDRATED TAR, naked *ex* works, or f.o.r. Sleaford Station.
Offers to the ENGINEER and MANAGER, SLEAFORD GAS COMPANY, LTD.

FOR SALE — Manual Retort Dis-CHARGER, by Morris, suitable for Retorts 11 ft. 6 in. long.
Further particulars may be obtained on application to the ENGINEER and MANAGER, SLEAFORD GAS COMPANY, LTD.

FOR SALE—Pair of Highest Class LANCASHIRE BOILERS, 30 ft. by 9 ft. diameter, by Spur-Inman, Wakefield, 1917. Complete Fittings (hand-fired). Reinsured 160 lbs. pressure. Price £300 each, loaded.
Address, No. 8074, "GAS JOURNAL," 11, BOLT COURT, FLEET STREET, E.C. 4.

FOR SALE — Two Crossley Gas ENGINES, S.E. Type, 30 H.P., with magneto ignition and compressed air starter, with Two Belt-Driven SIEMEN'S DYNAMOS, 220 volts, D.C. 100 amps.; also SWITCHBOARD, complete with suitable Instruments. In good running order. May be seen at work.
Apply to the BRIGHTON GAS COMPANY, 77, WEST STREET, BRIGHTON.

WANTED—One 20-Ton Second-Hand TAR STILL. Must be in good condition. Please state Makers' Name, Price, and where it may be inspected.
Communications to be addressed to the MARLEY HILL CHEMICAL COMPANY, LTD., MARLEY HILL, COUNTY OF DURHAM.

CONTRACTS OPEN.

BARNOLDSWICK URBAN DISTRICT COUNCIL.

(GAS AND WATER DEPARTMENT.)

TENDERS are invited for the Supply, Delivery, and Erection of a Set of Cast-Iron Vertical Water-Cooled CONDENSERS.
Specification and Drawing can be obtained from Mr. J. P. Thompson, Engineer and Manager, Gas-Works, Barnoldswick.
Sealed Tenders, endorsed "Condensers," to be delivered to the undersigned not later than 10 a.m. June 21, 1930.

ROBERT W. FENTON,
Clerk of the Council.

Town Hall,
Barnoldswick,
via Colne.

BARNOLDSWICK URBAN DISTRICT COUNCIL.

(GAS DEPARTMENT.)

THE above Council invite Tenders for the Supply and Delivery of GAS COAL required during the Year ending 30th June, 1931.
Approximate quantity required, 5000 Tons of WASHED DOUBLE-SCREENED GAS NUTS.
Sealed Tenders, endorsed "Gas Coal," to be forwarded to the undersigned so as to be received not later than 10 a.m. on Saturday, the 21st of June, 1930.
Forms of Tender are not issued.
The Council do not bind themselves to accept the lowest or any Tender.

ROBERT W. FENTON,
Clerk of the Council.

Town Hall,
Barnoldswick,
via Colne,
June 11, 1930.

PONTYPRIDD URBAN DISTRICT COUNCIL.

(GAS DEPARTMENT.)

TENDERS are invited for Repairs to a Half-Million Cubic Feet GASHOLDER, situate at Treforest Gas-Works, Pontypridd.
Particulars may be obtained from Mr. David Muir, Engineer and Manager, Gas-Works, Treforest.
Tenders, sealed and endorsed "Repairs to Column-Guided Gasholder," to be delivered to the undersigned not later than June 30, 1930.
The Council do not bind themselves to accept the lowest or any Tender.

H. LEONARD PORCHER,
Clerk of the Council.

Municipal Buildings,
Pontypridd,
June 4, 1930.

COUNTY BOROUGH OF WARRINGTON.

(GAS DEPARTMENT.)

THE Gas Committee invite Applica-tions from Firms wishing to Tender for the undermentioned GOODS as may be required during the next Twelve Months.
Full particulars may be had on application to the undersigned.
All enquiries must be made not later than June 30, 1930.

1. BAGS and STRING.
2. BRICKS, LIME, CEMENT, and SETTS.
3. CASTINGS.
4. COAL (SCREENED) and WASHED NUTS.
5. COOKERS, FIRES, &c.
6. DRY SALTERIES and VITRIOL.
7. FIRECLAY GOODS.
8. GAS FITTINGS.
9. GAS METERS.
10. GAS OIL.
11. GLASS.
12. IRONMONGERY, MILL FURNISHINGS, and GENERAL STORES.
13. IRON and STEEL.
14. LEAD and COMPO. PIPE.
15. MANTLES.
16. OILS, PAINTS, &c.
17. OXIDE (New or Spent).
18. PURCHASE of BYE-PRODUCTS.
19. RAILWAY MATERIALS.
20. STEEL and CAST MAINS.
21. TAPS, VALVES, &c.
22. TAR STILLS.
23. TIMBER.
24. WAGON REPAIRS.
25. WROUGHT IRON TUBES and FITTINGS.

A. COOK,
Engineer and Manager.

Offices:
Mersey Street,
Warrington,
June 10, 1930.

COUNTY BOROUGH OF ROCHDALE.

(GAS DEPARTMENT.)

THE Gas Committee of the above Council invite TENDERS for the Supply of GAS COAL as required during a period of Twelve Months ending June 30, 1931.
Forms of Tender may be obtained from the Engineer and Manager, Gas Department, Dane Street, Rochdale.
Tenders, endorsed "Coal," addressed to the Engineer and Manager, Gas Department, Dane Street, Rochdale, must be Delivered not later than noon on Wednesday, June 25, 1930.

By order,
WM. HENRY HICKSON,
Town Clerk.

Town Hall,
Rochdale,
June 11, 1930.

COUNTY BOROUGH OF ROCHDALE.

(GAS DEPARTMENT.)

TENDERS are invited for the Supply and Delivery by Road Tanks at the Gas-Works, Dane Street, Rochdale, of such quantity of Non-arsenical B.O. VITRIOL, 140° Twaddel, as may be required during a period of Twelve Months ending June 30, 1931.
Tenders, endorsed "Vitriol," addressed to the Engineer and Manager, Gas-Works, Rochdale, must be Delivered not later than noon on Wednesday, June 25, 1930.

By order,
WM. HENRY HICKSON,
Town Clerk.

Town Hall,
Rochdale,
June 11, 1930.

COUNTY BOROUGH OF ROCHDALE.

(GAS DEPARTMENT.)

TENDERS are invited for the Supply of NEW OXIDE OF IRON and the PURCHASE of SPENT OXIDE, f.o.r. Rochdale, during a period of Twelve Months ending June 30, 1931.
Separate or combined Tenders for each class may be submitted.
Tenders, endorsed "Oxide," addressed to the Engineer and Manager, Gas-Works, Rochdale, must be Delivered not later than noon on Wednesday, June 25, 1930.

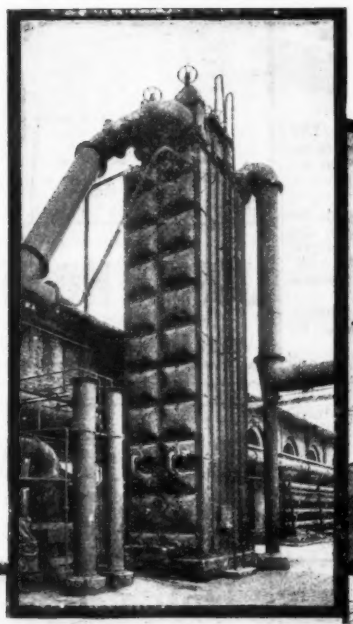
By order,
WM. HENRY HICKSON,
Town Clerk.

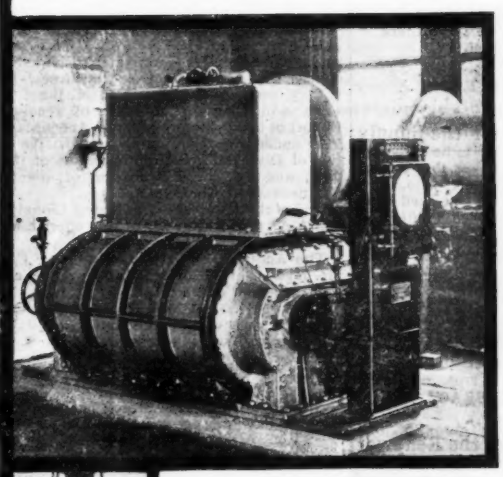
Town Hall,
Rochdale,
June 11, 1930.

XUM

A HOLMES INSTALLATION FOR THE YORK GAS COMPANY

1.





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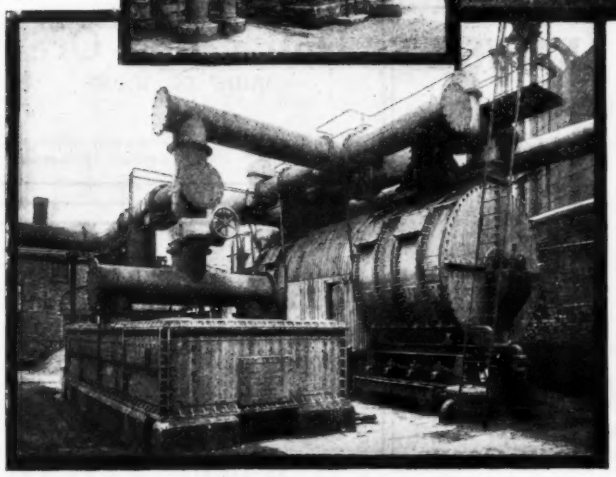

3.

This plant comprises:

1. A Super Type Condenser with Holmes patent Reversing Bye-pass, Tar Separator and Liquor Cooler below.

2. Rotary "Brush" Washer in two units, with Livesey Tar Extractor.

3. Connersville Meter for Carburetted Water Gas.

W. C. HOLMES & COMPANY, LIMITED

Head Office and Works:
TURNBRIDGE, HUDDERSFIELD
Telephone: 1573 Pvte. Branch Exch.
Telegrams: Holmes, Huddersfield.

Founded HOLMES 1850

London Office:
119, VICTORIA STREET, S.W.1
Telephone: Victoria 4505.
Telegrams: Ignitor, Sowest, London.

CONTRACTS OPEN.—*Continued.*

CITY AND COUNTY BOROUGH OF BELFAST.

(GAS DEPARTMENT.)

TENDERS are invited for the Supply of 180,000 Tons of GAS COAL, to be delivered free, and trimmed in Barges at Belfast Harbour, between the 1st of September, 1930, and the 31st of August, 1931.

Conditions and Forms of Tender may be had on Application to the Engineer and Manager, Gas-Works.

Tenders, enclosed in sealed envelopes, endorsed with the name and address of the Firm tendering and marked "Tender for Gas Coal, Gas Department," to be lodged in the Office of the undersigned not later than 5 p.m. on Thursday, the 19th of June, 1930.

An Official Receipt must be obtained for every Tender delivered by hand. Tenders sent by post should be registered.

The lowest or any Tender will not necessarily be accepted.

The whole or any part of a Tender may be accepted.

R. MEYER,
Town Clerk.

BOROUGH OF PONTEFRACT.

(GAS DEPARTMENT.)

TENDERS are invited for the Supply of 5000 Tons of GAS NUTS to be delivered at Monkhill Station, Pontefract, over the Twelve Months commencing the 1st of August, 1930.

Forms of Tender, which may be obtained from Mr. B. Hudson, Gas Engineer's Office, Pontefract, must be Delivered to the undersigned, endorsed "Gas Works Coal," not later than 12 noon on Monday, the 23rd of June, 1930.

F. M. FARMER,
Town Clerk.

Town Clerk's Office,
Pontefract.

BOROUGH OF PONTEFRACT.

(GAS DEPARTMENT.)

TENDERS are invited for the Renewal of One Bed of Eight RETORTS.

Sealed Tenders, endorsed "Retorts," should be Delivered to the undersigned not later than 12 noon on Monday, the 23rd of June, 1930.

Further particulars can be obtained from Mr. B. Hudson, Gas Engineer's Office, Pontefract.

F. M. FARMER,
Town Clerk.

Municipal Offices,
Pontefract.

GAS-WORKS FOR SALE.

re THE PONTARDULAIS GAS COMPANY, LTD.

TENDERS are invited for the Purchase AS A GOING CONCERN of the statutory undertaking of the above-named Company including: (1) The Leasehold Premises known as The Gas Works, Pontardulais, together with the piece or parcel of ground containing 1a. 1r. 35p. in the Parish of Llandilo, Talybont, held by the Company under a lease for a term of 99 years from the 29th of September, 1877, subject to a ground rent of £29 per annum, which premises are also subject to, and with the benefit of, two several Underleases, both dated the 29th of April, 1891, and respectively made between the Company of the one part, and John Mathias of the other part, at a ground rent of £7 10s. per annum, and George Hughes of the other part, at a ground rent of £6 10s. per annum; (2) The freehold plot of land containing 2r. 2op. or thereabouts, being part of the Undertaking; and (3) The Goodwill, Machinery and Plant, Pipes, Mains, Meters, and other Gas Apparatus of the Company, and the Office Furniture.

Tenders for the whole at a lump sum must be made in writing addressed to Mr. Evan Williams at the offices of the Company, Gas-Works, Pontardulais, before the 5th of July, 1930, and the person, Company, or Authority whose Tender is accepted, must on or before the 14th day of July, 1930, enter into a formal Contract (the form of which is open to inspection at the Offices of the Company), and pay a deposit of 10 per cent. on the amount of the purchase money. The Contract will be conditional on the following consents being obtained—namely, of the Judge of the Chancery Division in certain Debenture Holders' and Winding-up proceedings, and of the Board of Trade to make an Order under Section 10 of the Gas Regulation Act, 1920, transferring the Undertaking.

Full particulars of the Undertaking and Assets can be obtained by *bona-fide* enquiries from the SECRETARY, or from Messrs. DAHNE & THOMAS, Solicitors, PONTARDULAIS, and Messrs. HELDER ROBERTS & CO., 12, NEW COURT, LINCOLN'S INN, W.C. 2.

COMPANY NOTICES.

BARNET DISTRICT GAS AND WATER COMPANY.

NOTICE is Hereby Given that the TRANSFER BOOKS of this Company relating to DEBENTURE STOCK WILL BE CLOSED on the 24th of June, 1930, and RE-OPENED on the 1st of July, 1930.

By order of the Board,
E. D. DAVEY,
Secretary.

Offices:
139, Cannon Street,
London, E.C. 4,
June 6, 1930.

MALTA AND MEDITERRANEAN GAS COMPANY, LIMITED.

TO THE SHAREHOLDERS.

NOTICE is Hereby Given, that the ORDINARY GENERAL MEETING of the Shareholders of this Company will be held at the Offices, 59 & 60, Gracechurch Street, London, E.C. 3, on Tuesday, the 24th of June, 1930, at 11.30 a.m., for the purpose of receiving the Report of the Directors and the Accounts for the Year ended the 31st of March, 1930; the declaration of Dividends; the remuneration of the Auditors; and for the Transaction of the General Business of the Company.

One of the Directors, Mr. Ernest Lionel Burton, F.S.A.A., retires from office, and offers himself for re-election.

The Auditors, Mr. William Cash, F.C.A., and Mr. Hyde Clarke Burton, F.C.A., retire, and offer themselves for re-election.

The TRANSFER BOOKS WILL BE CLOSED from the 11th day of June until the day of the Meeting, both days inclusive.

By order of the Board,
C. J. DAUN,
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59 & 60, Gracechurch Street, E.C. 3,
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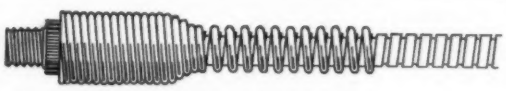

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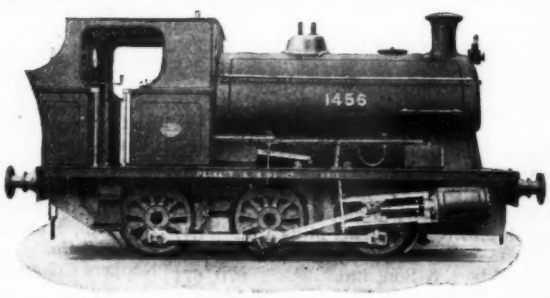

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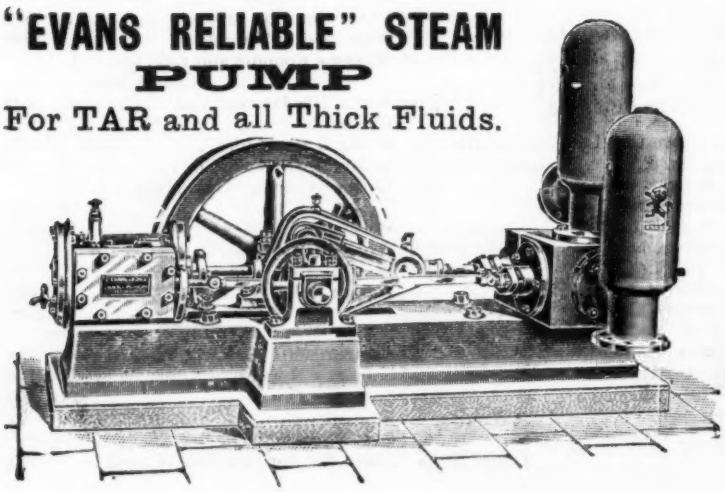

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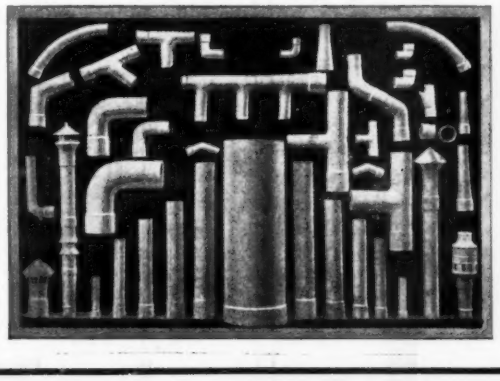

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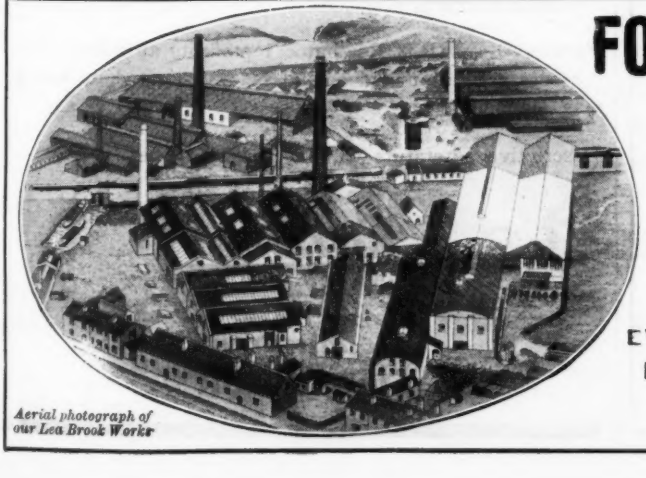

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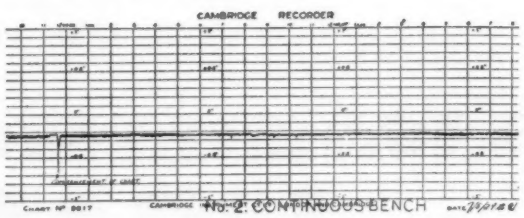

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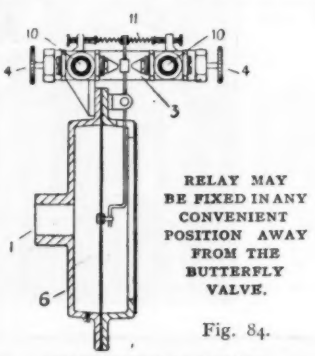

Fig. 84.
Relay Control in Section.

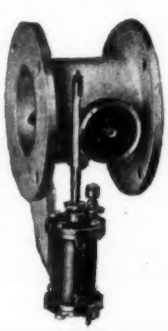

Fig. 81A.

Peebles' "B.V.R." Regulator represents an advance in pressure regulation and should be investigated by every Gas Manager.

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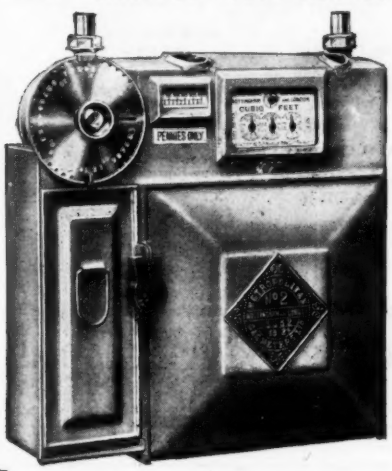

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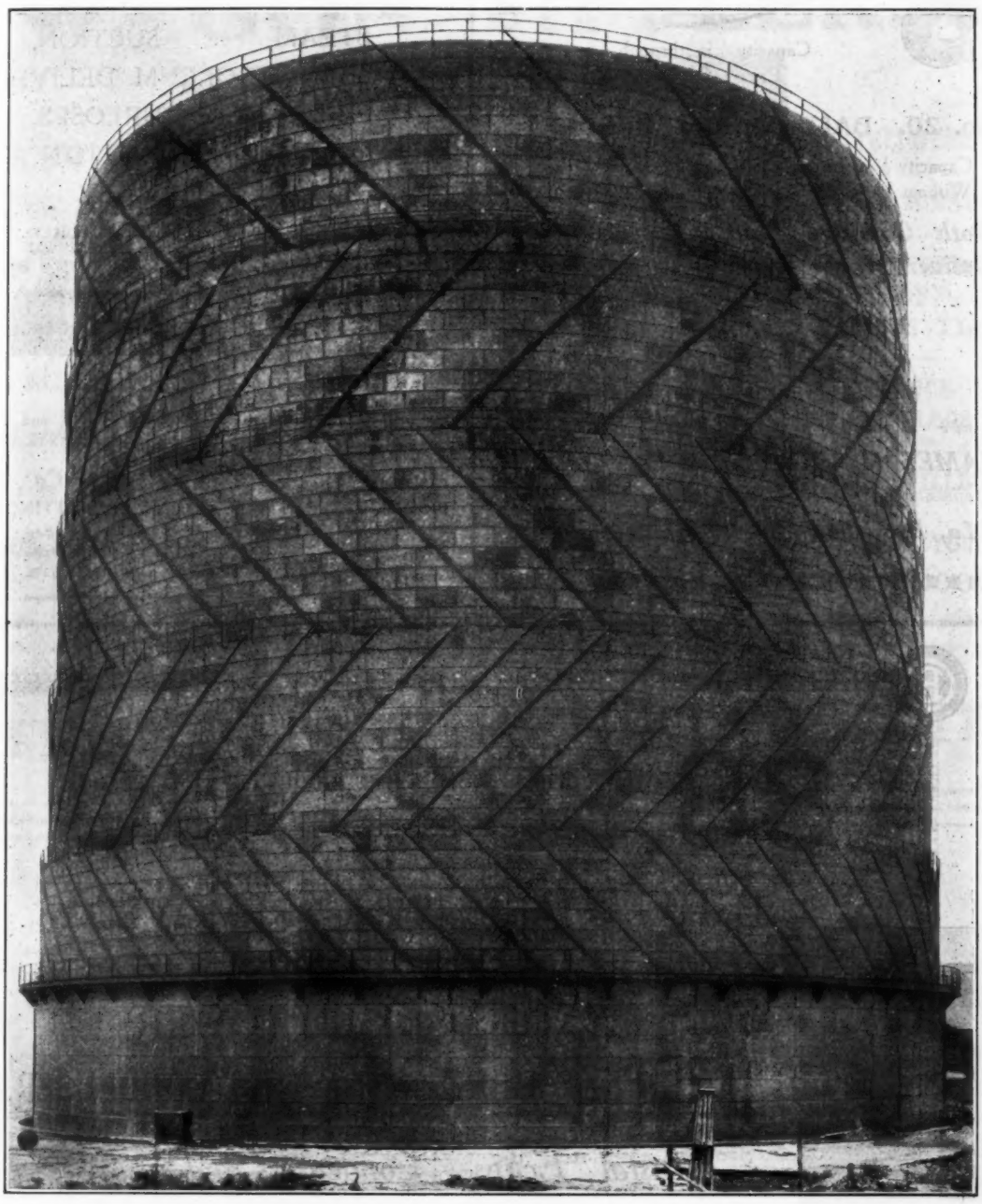

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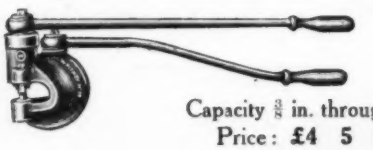

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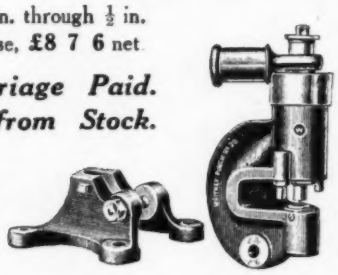

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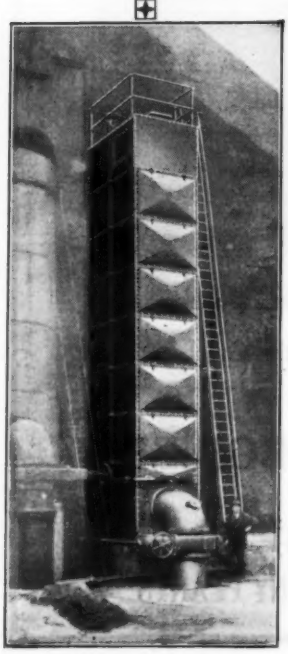

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